Alberta Energy Regulator

Directive 050

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Drilling Waste Management

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Contents

1 Introduction 6
1.1 Purpose 6
1.2 AER Requirements 6
1.3 Jurisdictional Overview 7
1.4 What's New in This Edition 7
1.5 Landowner/Department/Agency Consent 8
1.6 Reclamation Obligations for Sites Used to Manage Drilling Waste 9
2 Scope 10
2.1 Overview of Drilling Waste Management Methods 10
3 Soil Quality and Assessment for Sites Used to Manage Drilling Waste 12
3.1 Soil Endpoint Requirements 12
3.2 Soil Salinity Endpoint Requirements 12
3.3 Soil Hydrocarbon Endpoint Requirements 15
3.4 Soil Metal Endpoint Requirements 16
3.5 Receiving Soil Assessment and Disclosure of Exceedance of Soil Endpoint Requirements 19
4 Drilling Waste Assessment 21
4.1 General Drilling Waste Sampling and Assessment 21
4.2 Drilling Waste Sampling Requirements 21

4.3 Drilling Waste Assessment and Toxicity Requirements 22
4.4 Generic Mud System Requirements 24
4.5 Drilling Wastes Containing Radioactive Isotopes Requirements 27
5 Analytical and Field Screening Methods 28
5.1 Analytical Method Requirements 28
5.2 Field Screening Requirements 28
6 Storage of Drilling Waste 31
6.1 Introduction 31
6.2 General Drilling Waste Storage Requirements 31
6.3 Sump Construction Requirements 32
6.4 Remote Drilling Waste Storage Requirements 33
6.5 Earthen-bermed Storage System Requirements 34
6.6 Reuse of a Drilling Waste Storage System Requirements 35
6.7 Storage of Hydrocarbon-based Drilling Wastes Requirements 37
7 Management of Cement Returns 38
7.1 Introduction 38
7.2 Requirements 38
8 Drilling Wastes from Pipelines 41
8.1 Introduction 41
8.2 Requirements 41
9 Landspray 45
9.1 Introduction 45
9.2 Landspray Receiving Soil Requirements 45
9.3 Landspray Disposal Requirements 46
9.4 Landspray Post-disposal Requirements 49
10 Landspray While Drilling 51
10.1 Introduction 51
10.2 Landspray-While-Drilling Receiving Soil Requirements 51
10.3 Landspray-While-Drilling Disposal Requirements 52
10.4 Landspray-While-Drilling Post-disposal Requirements 55
11 Disposal onto Forested Public Lands 57
11.1 Introduction 57
11.2 Disposal onto Forested Public Lands Site and Receiving Soil Requirements 57
11.3 Disposal onto Forested Lands Disposal Requirements 59
11.4 Disposal onto Forested Public Lands Post-disposal Requirements 61

12 Pump-off 63
12.1 Introduction 63
12.2 Pump-off Receiving Soil Requirements 63
12.3 Pump-off Disposal Requirements 64
12.4 Pump-off Post-disposal Requirements 65
13 Mix-Bury-Cover 67
13.1 Introduction 67
13.2 Mix-Bury-Cover Receiving Soil Requirements 67
13.3 Mix-Bury-Cover Disposal Requirements 68
13.4 Mix-Bury-Cover Post-disposal Requirements 70
14 Landspreading 72
14.1 Introduction 72
14.2 Landspreading Receiving Soil Requirements 72
14.3 Landspreading Disposal Requirements 73
14.4 Landspreading Post-disposal Requirements 75
15 Biodegradation 77
15.1 Introduction 77
15.2 Drilling Waste and Site Characterization Requirements 77
15.3 Biodegradation of Drilling Waste by Land Treatment 82
15.3.1 Method Description 82
15.3.2 Design and Operation 82
15.4 Biodegradation of Drilling Wastes in a Contained System 84
15.4.1 Method Description 84
15.4.2 Design and Operation 85
15.4.3 Management Options for the Biodegraded Drilling Waste Removed from the Containment System 87
15.5 Information Requirements for Biodegradation Operations 88
16 Subsurface Disposal of Drilling Waste While Drilling 90
16.1 Introduction 90
16.2 Requirements 90
17 Sending Drilling Waste to Approved Waste Management Facilities 92
17.1 Introduction 92
17.2 Requirements 92
18 Use of Mobile Thermal Treatment Units to Manage Drilling Waste 96
18.1 Introduction 96
18.2 Thermally Treating Drilling Waste Requirements 96

19 Alternative Management Methods 99
19.1 Introduction 99
19.2 Alternative Management Methods Requirements 99
19.3 Application Information Requirements 99
20 Remixing a Former Drilling Waste Disposal 102
20.1 Introduction 102
20.2 Requirements to Remix a Former Drilling Waste Disposal 102
20.3 Notification Requirements 103
21 Record Keeping and Notification 105
21.1 Introduction 105
21.2 Record Keeping Requirements 105
21.3 Pre-disposal Notification Requirements 106
21.4 Post-disposal Notification Requirements 107

Appendices

1 *Directive 050* Background 108
2 Salinity and Nitrogen 110
3 Hydrocarbons 127
4 Metals 130
5 Toxicity Testing 133
6 Drilling Waste Sample Handling, Analytical Methods, and Calculations 141
7 Definitions of Terms as Used in *Directive 050* 151
8 Abbreviations 163
9 References 165

Figures

2.1 Overview of drilling waste management methods 11
4.1 Drilling waste toxicity assessment decision tree 26
5.1 Field QA/QC verification program 30

Tables

3.1 Soil salinity endpoints 13
3.2 Soil hydrocarbon endpoints (dry weight) 15
3.3 Hydrocarbon concentration in drilling waste 16
3.4 Soil metal endpoints—guideline values (dry weight) 17

3.5a Metal concentration in drilling waste 18
3.5b Concentration of boron in drilling waste (saturated paste extract) correlated to specific gravity of drilling waste 19
9.1 Summary of landspray disposal method 50
10.1 Summary of landspray-while-drilling disposal method 56
11.1 Summary of disposal onto forested public lands 62
12.1 Summary of pump-off disposal method 66
13.1 Summary of mix-bury-cover disposal method 71
14.1 Summary of landspreading disposal method 76

1 Introduction

The Alberta Energy Regulator (AER) *Directive 050: Drilling Waste Management* is incorporated by reference into the *Oil and Gas Conservation Rules* and sets out the requirements for the treatment and disposal of drilling waste generated in Alberta. Drilling waste is the mud and cuttings generated while

- drilling a well (including oil sands exploration wells), and
- directional drilling for pipeline construction.

The soil endpoints for the drilling waste land disposal methods in this edition of *Directive 050* have been aligned with the Government of Alberta's *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2016). While this will lead to better reclamation outcomes for land that is used for drilling waste disposal, industry is encouraged to develop alternatives to land disposal in support of the Alberta provincial policy of beneficial reuse of waste. This policy supports

- waste disposal to land when there are agronomic benefits, and
- the development of technology to improve waste recycling and reuse options and to reduce the volume of wastes sent for disposal (including land disposal).

1.1 Purpose

This directive is designed to

- provide the licensee of a well or pipeline with methods to manage drilling waste that are protective of the environment and harmonized with other waste management practices,
- enable sites used to manage drilling waste to be restored to equivalent land capability (see appendix 7 for definition), and
- ensure drilling waste management practices meet AER requirements and environmental outcomes through monitoring and reporting.

A fundamental principle of this directive is that the proper management of drilling waste is the responsibility of the licensee of the well or pipeline.

1.2 AER Requirements

Following AER requirements is mandatory for the responsible duty holder, as specified in legislation (e.g., licensee, operator, company, applicant, approval holder, or permit holder). The term "must" indicates a requirement, while terms such as "recommends" and "expects" indicate a recommended practice.

Each AER requirement is numbered.

Information on compliance and enforcement can be found on the AER website.

1.3 Jurisdictional Overview

Pursuant to the *Environmental Protection and Enhancement Act* (*EPEA*) and its regulations, Alberta Environment and Parks (EP) is responsible for developing soil and groundwater quality and remediation guidelines, setting policy for the application of risk assessments, and developing and maintaining reclamation requirements for lands designated as "specified lands" in *EPEA*. The AER is responsible for issuing reclamation certificates for specified lands where energy resource activities have taken place. In situations where the lands are not designated as specified lands, reclamation requirements are established by the department or agency managing the land on behalf of the provincial or federal Crown.

Pursuant to the *Oil and Gas Conservation Act* and its rules, the AER is responsible for developing and maintaining requirements for the management of oilfield wastes, including drilling waste, and for ensuring that these wastes are stored, treated, and disposed of in accordance with AER requirements. In doing so, the AER must align the waste management requirements with provincial soil quality and remediation guidelines, as well as with reclamation requirements. Should EP develop new soil quality guidelines or update existing soil remediation guidelines, licensees must adjust the endpoints specified (see tables 3.1, 3.2, and 3.4 accordingly).

1.4 What's New in This Edition

In February 2016, the Government of Alberta released a revised edition of *Alberta Tier 1 Soil and Groundwater Remediation Guidelines*. The AER identified four parameters—nickel, boron, ethylbenzene, and xylenes—for which soil endpoints and trigger concentrations for post-disposal sampling needed to be adjusted in *Directive 050*. As a result, this edition of the directive contains the following changes:

- The endpoints in table 3.2 (ethylbenzene and xylenes) and table 3.4 (nickel and boron) have been revised.
- The trigger concentrations in table 3.3 (ethylbenzene and xylenes) and table 3.5 (nickel and boron) have also been revised.

  With respect to boron, the change in the Tier 1 guidelines was accompanied by a change in the analytical method from hot water soluble to saturated paste extract. As a result, table 3.5 has been broken down into two tables: (a) and (b). Table 3.5a contains all the previous parameters except boron. Table 3.5b provides the trigger concentrations for boron in milligrams per litre

for saturated peats extract leachates) and extracts obtained from unsaturated waste streams. The formulas used to derive the trigger concentrations in table 3.7b have been added to appendix 4.

1.5 Landowner/Department/Agency Consent

A well site and pipeline right-of-way requires a written agreement from the landowner or from the department/agency managing the land on behalf of the provincial or federal Crown (e.g., a surface lease, a right-of-entry agreement, or a disposition under the *Public Lands Act*).

With the exception of burial of cement returns, additional landowner/department/agency consent is not required to manage drilling waste on the well site on which it was generated. Drilling waste from directional drilling activities for pipeline construction can be managed on the generating pipeline's pr[illegible] ay right-of-way without additional landowner/department/agency consent in situations where the surface of the right-of-way is disturbed (e.g., topsoil has been removed, right-of-way is under construction or has been disturbed for pipeline work). Consent is required to

- manage drilling waste from pipeline construction activities on the associated pipeline right-of-way when the surface of the right-of-way has been restored and is being used by the landowner/department/agency;
- manage drilling waste beyond the well site or pipeline right-of-way boundaries using the landspray, landspray-while-drilling, dispersal onto forested public lands, or pump-off method;
- store, mix-bury-cover, landspread, or biodegrade (i.e., land treat or biodegrade in a contained system) drilling waste on a [illegible] remote from the well site or pipeline right-of-way; and
- place cement returns in pits on a well site or remote drilling waste storage site when the collective area of one or more pits exceeds 4 m^2.

1) Licensees must provide a copy of a document called *Information for Landowners on Consent for the Disposal, Treatment, or Storage of Drilling Wastes* to the owners of any land on which licensees plan to manage drilling wastes; this includes well sites, remotes sites, and disturbed pipeline rights-of-way.

   This document and frequently asked questions on drilling waste management are located on the AER website at [illegible] under Rules and Directives > Directives > Directive 050.

Before consenting to have the drilling waste applied to their land, some landowners/departments/agencies may impose conditions in addition to the requirements set out in Directive 050. The decision regarding monitoring of additional conditions is between the landowner/department/agency and the licensee generating the drilling waste.

The following specifies the circumstances under which a landowner/leaseholder/government agency can provide consent/agreement for the purpose of Directive 058:

Land type	Landowner/leaseholder/agency for consent/agreement
Private land	Landowner
Public lands	AEP through the inspection and approval process under the *Public Lands Act*
First Nations lands	Indian Oil and Gas Canada (IOGC) or Indian and Northern Affairs Canada–Alberta Region must provide approval for the disposal of drilling waste on First Nation Indian Reserves. IOGC will facilitate the necessary approvals.
Métis settlement lands	Métis Settlement council
Canadian Forces Base Suffield (wholly owned federal lands)	Department of National Defence through consent from the base commander
Canadian Forces Base–Area Support Unit, Wainwright (mix of federally owned and leased provincial lands)	Department of National Defence through consent from the base commander and EP
Cold Lake Air Weapons Range (leased provincial lands)	Department of National Defence through consent from the wing commander and EP
Canadian Forces Base Cold Lake (wholly owned federal lands)	Department of National Defence through consent from the wing commander

1.6 Reclamation Obligations for Sites Used to Manage Drilling Waste

The methods used to store, non-burn-cover, landspread, and biodegrade drilling waste can require extensive drilling waste management and significant land disturbance, and licensees using these methods are required to reclaim the sites affected. If these methods are used on the well site, the affected area will typically be reclaimed when the well site is reclaimed. If a remote site is used to manage the drilling waste, licensees are responsible to reclaim the remote site to equivalent land capability.

Sites included under the definition of specified lands in LTO 3 are subject to the liquidated reclamation cost/bond process. For sites not included under the definition of specified lands, the reclamation process is through the Agreement or agency identified in section 1.5.

The methods used to landspray, landspray while drilling, and pump-off drilling waste are typically used beyond the boundaries of the well site or pipeline right-of-way and involve limited disturbance to land. Wells used to manage drilling wastes by these methods are not required to undergo the reclamation process.

The "disposal onto forested public lands" method is limited by the AEP to certain types of dispositions issued under the *Public Lands Act* (refer to section 1.5).

2 Scope

2.1 Overview of Drilling Waste Management Methods

The methods set out in this directive address the safe disposal or management techniques for drilling waste generated from one well, one multiwell licensed drilling program, or pipeline-related directional drilling (refer to Figure 2.1).

All the methods have specific requirements and limitations, and these, as well as the characteristics of the drilling waste, need to be considered when selecting a method. The methods addressed include

- storage of drilling waste on a well site, on a pipeline right-of-way, or at a remote site;
- landspray, landspray while drilling, disposal into licensed public lands, and spray-off of drilling waste onto surface soils (growth occurring naturally on well site boundaries);
- landspread and zero-burn cover of drilling waste into subsoils, occurring on a well site, on a pipeline right-of-way, or at a remote site;
- biodegradation of drilling waste, which includes land treatment or biodegradation in a contained volume, occurring on a well site or at a remote site;
- subsurface disposal of drilling waste down a well that is in the process of being drilled; and
- sending drilling waste to approved waste management facilities and the use of mobile thermal treatment units to manage drilling waste, as detailed in Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry and any subsequent updates to it, and as summarized in this edition of Directive 050.

Alteration of a drilling waste management method set out in this directive or use of a method not prescribed in this directive requires prior approval from the ERP (refer to sect. 10.11).

[redacted]

[redacted]

[redacted]

(a) [redacted]

(b) [redacted]

[redacted]

[redacted]

(a) [redacted]

(b) [redacted]

(c) [redacted]

[redacted]

Table 3.1 Soil salinity endpoints[1]

Disposal method	Receiving soil horizon, category[2], and limiting initial salinity criteria	Electrical conductivity (EC) changes from background soil conditions (dS/m)	Sodium adsorption ratio (SAR) changes from background soil conditions	Maximum sodium (Na) and nitrogen[3] (N) loading (kg/ha) and maximum [N] concentration (mg/kg)	Post-disposal soil sampling triggers
Pump-off	Topsoil Good category EC <2 dS/m SAR >8	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC, but not to exceed an EC of 2 dS/m	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil SAR, but not to exceed a SAR of 8	Na 250 N 25	Waste EC >5 dS/m N loading rate >25 kg/ha Na loading rate >150 kg/ha
Disposal onto forested public lands	Topsoil Good category EC <2 dS/m SAR >8	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC, but not to exceed an EC of 2 dS/m	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil SAR, but not to exceed a SAR of 8	Na 250 N 25	Waste EC >5 dS/m N loading rate >25 kg/ha Na loading rate >150 kg/ha
Landspray landfarm units drilling	Topsoil Good category EC <2 dS/m SAR >8	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC, but not to exceed an EC of 2 dS/m	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil SAR, but not to exceed a SAR of 8	Na 250 N 25	Waste EC >10 dS/m N loading rate >25 kg/ha Na loading rate >150 kg/ha
Landspread soil treatment	Subsoil[4] to 1 m Good category EC <10 dS/m SAR >8	Soil/waste mix limited to a maximum increase of 2 units beyond background soil EC, but not to exceed an EC of 3 dS/m	Soil/waste mix limited to a maximum increase of 3 units beyond background soil SAR, but not to exceed a SAR of 8	Na 500 N 400	Landspread only: waste EC > 8 dS/m or [Na] >2000 mg/L, or N loading rate >300 kg/ha
Landspread soil treatment	Subsoil to 1 m Fair category EC of 5 to 8 dS/m SAR of 8 to 8	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC	Soil/waste mix limited to a maximum increase of 2 units beyond background soil SAR	Na not applicable N 400	Landspread only: waste EC >8 dS/m or [Na] >2000 mg/L, or N loading rate >300 kg/ha

(continued)

Disposal method	Receiving soil horizon, category[2], and limiting initial salinity criteria	Electrical conductivity (EC) changes from background soil conditions (dS/m)	Sodium adsorption ratio (SAR) changes from background soil conditions	Maximum sodium (Na) and nitrogen[3] (N) loading (kg/ha) and maximum [N] concentration (mg/kg)	Post-disposal soil sampling triggers
Mix-bury-cover	Subsoil[6] between 1 and 1.5 m Good or fair category EC ≤5 SAR ≤8	Soil/waste mix limited to a maximum increase of 2 units beyond background soil EC	Soil/waste mix limited to a maximum increase of 4 units beyond background soil SAR	Na not applicable [N] coarse soil[7] = 10 mg/kg or [N] fine soil[8] = 40 mg/kg	Waste EC >10 dS/m or [Na] >3000 mg/L , or [N] (wet weight) for coarse soil disposal ≥6 mg/kg or fine soil disposal ≥120 mg/kg
Mix-bury-cover	Subsoil 1.5 m and deeper Good, fair, poor, or unsuitable category	Soil/waste mix limited to a maximum increase of 3 units beyond background soil EC	Soil/waste mix limited to a maximum increase of 6 units beyond background soil SAR	Na not applicable [N] coarse soil[7] = 10 mg/kg or [N] fine soil[8] = 40 mg/kg	Waste EC >10 dS/m or [Na] >3000 mg/L, or [N] (wet weight) for coarse soil disposal ≥6 mg/kg or fine soil disposal ≥120 mg/kg

[1] Caution must be exercised when applying saline waste to hay and pasture land where salt-sensitive species are growing. Salt-sensitive species include red clover, alsike clover, alfalfa, and timothy. The potential for damage to vegetation is especially high when the soil is dry. Use extreme caution when conducting disposals on no-till fields in the spring prior to seeding.

[2] Receiving soil categories are defined in accordance with Alberta Environment's *Salt Contamination Assessment and Remediation Guidelines* (2001).

[3] Total mineral nitrogen (i.e., ammonium-nitrogen, nitrate-nitrogen, and nitrite-nitrogen) and the loading rate must be prorated to the actual area of land used for disposal.

[4] Topsoil is the uppermost layer(s) of soil that consists of the L, F, H, O, or A horizons or the depth of tillage, whichever is greater.

[5] Some plant species will be sensitive to salinity levels below 2 dS/m (e.g., flax, clover, beans, some wheat varieties, peas, some garden crops, and some forest species). Drilling waste disposal must not cause adverse effects to these species.

[6] Subsoil is the layer of soil directly below the topsoil. It consists of the B and C horizons and extends to bedrock. For salinity management, three depths are recognized: top of the subsoil to a depth of 1 m; subsoil from >1 m to 1.5 m; and subsoil at a depth >1.5 m.

[7] Coarse soils have a median grain size >75 microns.

[8] Fine soils have a median grain size ≤75 microns.

3.3 Soil Hydrocarbon Endpoint Requirements

Table 3.2 sets out the hydrocarbon soil quality endpoints for soils receiving drilling wastes. Endpoints are identified for coarse- and fine-grain soils for three different land uses: natural area, agricultural, and residential/parkland. Refer to appendix 3 for guidance on predicting hydrocarbon concentrations in soil/waste mixes and the rationale for protocol revisions related to hydrocarbon endpoints. Refer to appendix 6 for equations used to predict application rates.

5) Licensees must prevent soils that receive drilling wastes from exceeding the hydrocarbon endpoints set out in table 3.2.

   In situations where the concentration of any of the hydrocarbon fractions (i.e., benzene, toluene, ethyl benzene, and xylenes [BTEX] and hydrocarbon fractions F1 through F4) in the drilling waste exceeds the concentration listed in table 3.3 as correlated to the specific gravity of the drilling waste, licensees will be required to sample the receiving soil/waste mix within 60 days of the disposal and analyze it to verify that the endpoints in table 3.2 were not exceeded. Details respecting these requirements are set out in the section specific to each disposal method.

Table 3.2 Soil hydrocarbon endpoints (dry weight)

	Natural area land use		Agricultural land use		Residential/parkland land use	
Hydrocarbon fraction	**Fine soil[1] (mg/kg)**	**Coarse soil[2] (mg/kg)**	**Fine soil (mg/kg)**	**Coarse soil (mg/kg)**	**Fine soil (mg/kg)**	**Coarse soil (mg/kg)**
F1 (C6–C10, excluding BTEX)	210	210	210	24	210	24
F2 (>C10–C16)	150	150	150	130	150	130
F3 (>C16–C34)	1300	300	1300	300	1300	300
F4 (>C34)	5600	2800	5600	2800	5600	2800
Benzene	0.046	0.078	0.046	0.073	0.046	0.073
Toluene	0.52	0.12	0.52	0.12	0.52	0.12
Ethylbenzene	0.073	0.14	0.073	0.14	0.073	0.14
Xylenes	0.99	1.9	0.99	1.9	0.99	1.9

[1] Fine soils have a median grain size ≤75 microns.

[2] Coarse soils have a median grain size >75 microns.

Table 3.3 Hydrocarbon concentration in drilling waste

		Concentration of hydrocarbon fraction in drilling waste (wet and dry weight in mg/kg) correlated to specific gravity (SG) of drilling waste[1]							
Waste SG	Parameter	F1	F2	F3	F4	Benzene	Toluene	Ethyl-benzene	Xylenes
1.1	Wet Wt.	104	565	1 304	12 169	0.20	0.52	0.32	4.3
	Dry Wt.	714	3870	8 930	83 345	1.37	3.57	2.20	29
1.2	Wet Wt.	99	535	1 235	11 529	0.19	0.49	0.30	4.1
	Dry Wt.	369	2000	4 615	43 072	0.71	1.85	1.10	15
1.3	Wet Wt.	94	510	1 177	10 989	0.18	0.47	0.29	3.9
	Dry Wt.	254	1377	3 177	29 648	0.49	1.27	0.77	10.5
1.4	Wet Wt.	90	489	1 128	10 525	0.17	0.45	0.27	3.7
	Dry Wt.	197	1065	2 457	22 936	0.38	0.98	0.60	8.1
1.5	Wet Wt.	87	470	1 085	10 123	0.17	0.43	0.26	3.6
	Dry Wt.	162	878	2 026	18 909	0.31	0.81	0.49	6.7
1.6	Wet Wt.	84	454	1 047	9 771	0.16	0.42	0.25	3.5
	Dry Wt.	139	753	1 738	16 224	0.27	0.70	0.42	5.7
1.7	Wet Wt.	81	439	1 014	9 461	0.16	0.41	0.25	3.3
	Dry Wt.	123	664	1 533	14 306	0.24	0.61	0.37	5.1
1.8	Wet Wt.	79	426	984	9 185	0.15	0.39	0.24	3.2
	Dry Wt.	110	597	1 379	12 868	0.21	0.55	0.34	4.5
1.9	Wet Wt.	77	415	958	8 939	0.15	0.38	0.23	3.2
	Dry Wt.	101	546	1 259	11 749	0.19	0.50	0.31	4.2
2.0	Wet Wt.	75	405	934	8 716	0.14	0.37	0.23	3.1
	Dry Wt.	93	504	1 163	10 854	0.18	0.47	0.28	3.8
2.1	Wet Wt.	73	395	912	8 516	0.14	0.36	0.22	3.0
	Dry Wt.	87	470	1 085	10 122	0.17	0.43	0.26	3.6
2.2	Wet Wt.	71	387	893	8 333	0.14	0.36	0.22	2.9
	Dry Wt.	82	442	1 019	9 512	0.16	0.41	0.25	3.4
2.3	Wet Wt.	70	379	875	8 166	0.13	0.35	0.21	2.9
	Dry Wt.	77	418	964	8 996	0.15	0.39	0.23	3.2
2.4	Wet Wt.	69	372	859	8 013	0.13	0.34	0.21	2.8
	Dry Wt.	73	397	916	8 553	0.14	0.37	0.22	3.0
2.5	Wet Wt.	67	366	843	7 873	0.13	0.34	0.21	2.8
	Dry Wt.	70	379	875	8 170	0.13	0.35	0.21	2.9

[1] Calculated using Alberta Tier 1 de-minimus guideline values, a soil-to-waste mix ratio of 3:1, and a soil dry bulk density of 1540 kg/m^3.

3.4 Soil Metal Endpoint Requirements

Table 3.4 sets out the metal soil quality endpoints for soils receiving drilling wastes. Licensees are expected to review the drilling mud additives that will be used in their drilling mud system to determine if barite is present. If barite is present in the drilling mud system, licensees are to use the barium fusion inductively coupled plasma analysis method to determine the barite concentration. If it is determined that barite is not used in the drilling mud system, the total digest method is to be

used to determine the total barium concentration. In situations where the soil/waste mix is expected to exceed the total barium value, licensees can follow Alberta Environment's *Soil Remediation Guidelines for Barite* (2009) to determine if the barite guidelines can be used at a particular site. Refer to appendix 4 for guidance predicting metal concentrations in drilling wastes and soil/waste mixes. Refer to appendix 6 for equations used to predict application rates.

6) Licensees must prevent soils that receive drilling wastes from exceeding the metal endpoints set out in table 3.4 for the appropriate land use.

   In situations where the concentration of any metal in the drilling waste exceeds the concentrations listed in table 3.5a or b as correlated to the specific gravity of the drilling waste, licensees will be required to sample the receiving soil/waste mix within 60 days of the disposal and analyze it to verify that the endpoints in table 3.4 were not exceeded. Details respecting these requirements are set out in the section specific to each disposal method.

Table 3.4 Soil metal endpoints—guideline values (dry weight)

	Guideline value (mg/kg except boron)		
Metal	Agricultural land use	Natural area land use	Residential/parkland land use
Antimony	20	20	20
Arsenic (inorganic)	17	17	17
Barium	750	750	500
Barite-barium[1]	10 000	10 000	10 000
Beryllium	5	5	5
Boron (mg/L saturated paste extract)	3.3	3.3	3.3
Cadmium	1.4	3.8	10
Chromium (total)	64	64	64
Chromium (hexavalent)	0.4	0.4	0.4
Cobalt	20	20	20
Copper	63	63	63
Lead	70	70	140
Mercury (inorganic)	6.6	12	6.6
Molybdenum	4	4	4
Nickel	45	45	45
Selenium	1	1	1
Silver	20	20	20
Thallium	1	1	1
Tin	5	5	5
Uranium	23	33	23
Vanadium	130	130	130
Zinc	200	200	200

[1] Alberta Environment's *Soil Remediation Guidelines for Barite* (2009) must be followed to determine if the site qualifies as a barite site. If it does not, then the 750 mg/kg total barium value applies.

Table 3.5a Metal concentration in drilling waste

		Concentration of metal in drilling waste (wet and dry weight in mg/kg) correlated to specific gravity (SG) of drilling waste[1]																					
Waste 99[2]	Parameter																						
1.1	Wet Wt	55	49	2 500	43 000	25	5.2	200	1.7	51	210	260	29	14	100	2.7	85	3.6	16	42	450	630
	Dry Wt	382	333	17 147	292 482	146	35.9	1 366	11.5	350	1 415	1 788	195	95	691	18.5	587	24.6	109	287	3 084	4 340
1.2	Wet Wt	52	47	2 400	40 900	19	5.0	190	1.6	52	200	250	27	14	101	2.6	81	3.4	15	41	430	604
	Dry Wt	359	175	0 648	151 241	73	10.7	711	6.1	195	750	953	101	51	376	9.6	305	12.6	57	225	1 597	2 242
1.3	Wet Wt	78	45	2 304	39 000	19	4.8	180	1.6	50	190	240	26	13	96	2.5	77	3.3	15	40	410	580
	Dry Wt	211	122	6 216	104 101	50	12.9	485	4.2	135	514	645	70	35	259	6.8	208	8.8	40	104	1 105	1 562
1.4	Wet Wt	75	44	2 230	37 000	18	4.6	180	1.5	48	180	230	25	13	97	2.4	74	3.2	14	40	400	560
	Dry Wt	103	58	4 849	80 621	39	10.0	380	3.3	105	401	501	54	28	210	5.3	162	6.9	31	174	864	1 217
1.5	Wet Wt	72	43	2 200	36 000	17	4.4	170	1.4	46	180	220	24	12	94	2.4	73	3.1	14	39	390	540
	Dry Wt	134	80	4 029	66 486	32	8.3	323	2.7	89	355	415	46	25	177	4.5	135	5.7	26	148	717	1 001
1.6	Wet Wt	69	42	2 130	34 500	17	4.3	170	1.4	47	170	220	23	12	94	2.3	69	3.0	13	38	370	520
	Dry Wt	115	70	3 483	57 645	28	7.2	280	2.3	79	288	368	38	20	155	3.8	114	4.9	22	124	615	861
1.7	Wet Wt	67	41	2 500	33 000	16	4.2	170	1.3	45	170	210	23	12	92	2.3	67	2.9	13	37	360	500
	Dry Wt	102	62	3 882	50 355	24	6.3	249	2.0	69	259	317	34	18	140	3.5	101	4.4	20	108	548	764
1.8	Wet Wt	65	40	2 300	32 000	16	4.1	160	1.3	45	170	200	23	11	91	2.3	65	2.8	13	36	350	490
	Dry Wt	91	57	2 866	45 316	22	5.7	230	1.8	63	232	288	33	16	129	3.2	91	3.9	18	49	497	711
1.9	Wet Wt	64	40	2 300	31 000	15	4.0	160	1.3	44	160	200	23	11	90	2.2	63	2.8	13	35	350	490
	Dry Wt	84	52	2 572	41 387	20	5.2	208	1.7	58	213	262	29	15	115	2.9	83	3.6	17	46	458	654
2.0	Wet Wt	62	39	1 900	31 000	15	3.9	160	1.2	44	160	200	22	11	88	2.2	62	2.7	12	37	340	480
	Dry Wt	77	49	2 380	38 248	19	4.8	193	1.5	55	199	243	28	13	111	2.7	77	3.4	16	50	423	606
2.1	Wet Wt	61	39	1 900	30 000	15	3.9	150	1.2	43	160	190	22	11	88	2.2	60	2.6	12	36	330	460
	Dry Wt	72	45	2 241	35 686	17	4.6	182	1.4	51	188	227	26	13	105	2.6	73	3.1	14	42	397	571
2.2	Wet Wt	59	38	1 900	29 000	14	3.7	150	1.2	43	150	190	22	10	86	2.1	59	2.6	12	34	320	470
	Dry Wt	68	43	2 116	33 545	16	4.3	172	1.4	49	176	214	22	12	100	2.4	67	3.0	14	79	370	540
2.3	Wet Wt	58	38	1 800	29 000	14	3.7	150	1.2	42	150	180	19	10	87	2.1	59	2.6	12	33	320	470
	Dry Wt	84	61	2 611	31 729	15	4.1	184	1.3	47	187	253	21	11	98	2.5	84	3.6	15	80	356	514
2.4	Wet Wt	57	37	1 800	28 000	14	3.6	150	1.1	42	150	180	19	10	86	2.1	57	2.5	12	32	320	450
	Dry Wt	91	48	1 931	30 177	15	3.9	156	1.2	45	163	193	20	11	92	2.2	86	2.7	12	68	445	462
2.5	Wet Wt	56	37	1 800	28 000	14	3.6	150	1.1	41	150	180	19	10	86	2.1	56	2.5	12	31	310	460
	Dry Wt	69	38	1 846	28 802	14	3.7	156	1.2	43	153	185	19	10	89	2.2	59	2.6	12	63	295	472
Background metal value used		0.12	6	100	100	0.3	0.2	10	0.032[3]	8	15	10	0.03	0.7	22	0.4	0.3	0.15	1.4	2	35	95

[1] Calculated using Alberta-specific metal background values (except Canadian Council of Ministers of the Environment's Soil Quality Guidelines for the Protection of Environmental and Human Health used for uranium), Alberta Tier 1 (or-minimum guideline values), a soil-to-waste mix ratio of 2:1, and a soil dry bulk density of 1946 kg/m³.

[2] Refer to appendix 4, section A6.2.1, for information on specific gravity.

[3] Median value used for background.

Table 3.6b Boron concentration in drilling waste (saturated paste extract) correlated to specific gravity of drilling waste[1]

Waste specific gravity	Boron in waste filtrate[2] (mg/L)	Boron in waste saturated paste[2] (mg/L)
1.1	5	30
1.2	6	35
1.3	10	60
1.4	11	70
1.5	13	8
1.6	14	8
1.7	15	7
1.8	16	9
1.9	17	9
2.0	20	9
2.1	21	9
2.2	22	9
2.3	23	9
2.4	75	9
2.5	125	9

[1] Calculated using Alberta-specific model background soils, Alberta Tier 1 soil criteria guideline values, a soil to water mix ratio of 2:1, and a soil dry bulk density of 1500 kg/m³

[2] Background boron value used: 0.1

3.5 Receiving Soil Assessment and Disclosure of Exceedances of Soil Endpoint Requirements

The application of drilling waste to soil requires assessment of the receiving soil conditions at the disposal location and the soil/waste mixing depth for the specific disposal method. Receptor exposure zone requirements are set out in the section specific to each disposal method.

7) When assessing receiving soil conditions, licensees must ensure that each sampling site is representative of

   a) the landscape in the proposed disposal area and of the most sensitive part of the landscape (e.g., convergent landscapes and landscapes are usually the most sensitive parts of the landscape and may have naturally higher levels of sodium and salinity or may have concentrated parameters from previous drilling waste disposals), and

   b) any previous drilling waste disposals within the disposal area.

8) When using a field screening program to determine initial soil salinity and suitability for receipt of drilling wastes, licensees must ensure that the field screening program is supported by an ongoing quality assurance/quality control program as set out in section 9.

(b) Where post-disposal sampling of the contaminated mix is required, licensees must:

(a) have the samples [illegible] following the [illegible] and
(b) have the samples [illegible] following the [illegible] and

(c) ensure soil particle size analysis, chemical characterization of samples of the soil or soil/water mix when analyzing for the hydrocarbon fractions set out in table [illegible]

(4) In situations where post-disposal sample results exceed any of the soil endpoints in tables [illegible], licensees must electronically submit a notification to the AER disclosing the exceedance as a noncompliance event. The notice of disclosure must describe the situation (i.e., the type of disposal and drilling waste) and the soil endpoints that are exceeded and contain a plan to remediate it (i.e., subject to [illegible]).

(5) Licensees must electronically submit the notification to the AER in PDF as an e-mail attachment as follows:

(a) E-mail the [illegible]

(b) Ensure that the attachment file name identifies it as a drilling waste disposal endpoint exceedance disclosure, contains the applicable well license number and the unique well identifier (UWI) of the well that generated the drilling waste or to which it is linked, and is formatted as [illegible]

(c) Ensure that the subject field of the e-mail contains the file name.

The AER will review notifications that do not address all of the required information in the licensee and will consider commencement of any [illegible] associated with the notification as a noncompliance.

6 [redacted]

6.1 [redacted]

[redacted]

6.2 [redacted]

1. [redacted]
2. [redacted]
3. [redacted]
4. [redacted]
5. [redacted]
6. [redacted]
7. [redacted]
8. [redacted]
9. [redacted]

(3) If in-field treatments are conducted (e.g., pH adjustment, aeration) to reduce drilling waste toxicity, licensees must resample and test the drilling waste to determine if it meets the toxicity requirements. Additional lab testing may be required to determine whether field treatment methods will reduce toxicity. See figure 4.1, which outlines the decision-making process described in this section.

4.4 Generic Mud System Requirements

To help decide whether to use the landspray, landspray-while-drilling, and disposal onto forested public lands methods of managing drilling wastes (alleviate uncertainties about metal content and toxicity), licensees can develop a generic mud system, analyze it, and use the results to determine the applicability of each disposal method.

Licensees using the generic mud system have to follow minimum requirements.

(1) Licensees must

a) develop a generic mud system that mimics the mud formulation that will be used for the drilling program (must contain the highest concentration of individual mud products/fluid additives that would be used in the mud system), and

b) test the mud system for metals (listed in table 7-8), toxicity (luminescent bacteria), and salinity (EC, SAR, Na, Na/Al, Na/Ca, Na/Mg, Na/K).

Note: The generic mud system is to be lab tested before being used for drilling.

(2) Licensees must only proceed with plans to use the landspray, landspray-while-drilling, and disposal onto forested public lands drilling waste management methods if the generic mud system

a) passes the luminescent bacteria toxicity test,

b) contains metal concentrations that would not result in exceedances of the soil metal endpoints in table 7-8, and

c) does not have salinities that would result in exceedances of the salinity endpoints set out in table 7-8.

Note: Using a generic mud system does not enable licensees to forego field screening to assess the applicability of a drilling waste management method.

24) Licensees must re-evaluate use of the landspray, landspray-while-drilling, or disposal onto forested public lands method if drilling operations result in changes to the drilling mud/waste system (i.e., increase the concentration of fluid additives/mud products, add new fluid additives/mud products, or encounter a hydrocarbon flag), and only continue with use of the method if the requirements specific to it can be met.

25) Licensees must monitor changes from the generic mud system by sampling drilling waste from 5 per cent of the wells drilled as part of the drilling program, or a minimum of two wells (for small drilling programs where 5 per cent would be less than two wells) and test the samples for toxicity and metals. Disposal may proceed before the results are received if all other requirements for the landspray, landspray-while-drilling, or disposal onto forested public lands method are met.

26) If drilling waste sampling results identify either metal content in excess of any of the values in table 3.5a or b or toxicity threshold failure, licensees must sample the disposal area (drilling waste/soil mix) and analyze the samples to determine compliance with endpoints set out in tables 3.1, 3.2, and 3.4.

27) If disposal area sampling results identify any exceedance of the endpoints in tables 3.1, 3.2, or 3.4, licensees must re-evaluate the appropriateness of the landspray, landspray-while-drilling, and disposal onto forested public lands disposal methods for the remainder of the drilling program.

Note: Exceedances of soil endpoints are to be disclosed to the AER (refer to section 3.5).

Refer to sections 9, 10, and 11 for additional post-disposal sampling and analysis requirements based on drilling waste salinity and hydrocarbon content.

Figure 4.1 Drilling waste toxicity assessment decision tree

4.5 Drilling Wastes Containing Radioactive Isotopes Requirements

Radioactive isotopes are sometimes added to drilling mud systems as tracers, in which case they will also be in the resulting drilling waste.

The disposal of radioactive isotopes is regulated by the Canadian Nuclear Safety Commission (CNSC) in accordance with the *Nuclear Substances and Radiation Devices Regulations*, which falls under the *Nuclear Safety Control Act*. Pursuant to section 5.1 in the *Nuclear Substances and Radiation Devices Regulations*,

> a person may, without a license, abandon or dispose of a radioactive nuclear substance if the activity or the activity concentration of the substance does not exceed its exemption quantity, conditional clearance level, or unconditional clearance level.

Drilling wastes containing radioactive isotopes are subject to the CNSC regulations, so only those with concentrations less than the prescribed quantities can be land-applied following the methods outlined in *Directive 50*.

28) When land applying drilling waste containing radioactive isotopes following a method in *Directive 050*, licensees must

   a) ensure that the concentration of the radioactive isotope that is used is documented and retained in the well file, including any conversion factors used to demonstrate that the resulting concentration in the drilling wastes is below the prescribed limits; and

   b) disclose to relevant landowners that drilling wastes to be disposed on their land contain radioactive isotopes.

29) Should the radioactive isotope concentration within a drilling waste be subject to CNSC regulation, licensees must also ensure that the drilling waste management method complies with AER requirements.

For information on control and disposal of recirculated radioactive contaminated sand from fracturing, refer to *Directive 058*, section 32, "Radioactive Contaminated Oilfield Wastes."

5 Analytical and Field Screening Methods

5.1 Analytical Method Requirements

Due to technical advances, many documented methods rapidly become obsolete. Consequently, a complete list of analytical protocols is not provided with this document.

1) To assess drilling wastes, soils, and soil/waste mixes, licensees must use recognized and published analytical methods, preferably ones for which Standard Council of Canada (SCC) or Canadian Association For Laboratory Accreditation (CALA) recognition has been obtained or is expected. Both SCC and CALA are full signatory members of the International Laboratory Accreditation Cooperation (ILAC). ILAC recognition requires that the accrediting body operate its accreditation program according to the international standard ISO/IEC 17011, that lab accreditations be based on ISO/IEC 17025, and that periodic evaluations be conducted by a team of experts.

2) When using an alternative analytical method, licensees must support its use using data that show the method's equivalence to an appropriate accredited method.

Refer to appendix 9 for references on analytical methods.

5.2 Field Screening Requirements

3) Licensees must limit use of field screening test methods to assessing

   a) the suitability of soils to receive drilling wastes,

   b) the suitability of drilling wastes to be managed by landspray while drilling and disposal onto forested public lands,

   c) the minor treatment of drilling wastes in the field (e.g., pH adjustment), and

   d) the suitability for disposal of pipeline drilling wastes composed solely of bentonite and fresh water.

4) Licensees must limit parameters assessed by field screening test methods to pH, EC, SAR (magnesium, sodium, calcium), nitrogen (NH_3-N, NO_3-N, NO_2-N), and hydrocarbons (i.e., BTEX and F1, F2, F3, and F4 fractions).

5) When choosing a field screening test method, licensees must ensure that

   a) the detection range of the chosen method is appropriate for the characteristics of the wastes or receiving soils being measured, and

   b) the detection limit of the test encompasses the criteria the sample is being evaluated against (e.g., for receiving soils that must have an EC below 2 dS/m, the method chosen to analyze the receiving soil sample must have a detection range below and above 2 dS/m).

6) Licensees must ensure that all field screening programs are supported by an ongoing quality assurance/quality control (QA/QC) program that includes

   a) training of field personnel on methods and instrumentation,

   b) equipment/instrument calibration and maintenance programs,

   c) documented standard operating procedures, and

   d) verification of data quality objectives (e.g., lab truthing, use of duplicates and blanks, use of analytical methods in the correct range).

7) Licensees must lab verify 5 per cent of field measurements and one receiving soil sample per well and

   a) if any of the lab results are higher than the field results, recalculate the loading rates or spread rates using the lab results.

   b) if the recalculated loading or spread rates exceed *Directive 050* soil endpoints, sample the receiving field (soil/waste mixture) post-disposal.

   Note: Exceedance of soil endpoints are to be disclosed to the AER (refer to section 3.5).

8) Licensees must ensure that the lab used to verify measurements from field screening programs and to analyze soil/waste mixes have QA/QC programs in place and are using analytical methods as specified in section 5.1.

   Refer to figure 5.1 for a summary.

Field Analysis
Lab Analysis
Waste representatively sampled
Field analysis supports Directive 050 disposal feasible?
Lab analysis supports Directive 050 disposal feasible?
(treat and resample waste)
YES
NO
NO
YES
YES
Proceed with disposal as per Directive 050
Treatment possible?
Proceed with disposal as per Directive 050
NO
Disposal as per Directive 058
5% of field samples and 1 receiving soil sample per well duplicated and sent to certified lab as part of field QA/QC verification program
Review calculations with lab-generated numbers. New calculations still confirm compliance?
YES
No further action required
NO
Post-disposal sampling of all potentially impacted receiving fields required. Do results indicate soils meet Directive 050 endpoint criteria?
YES
No further action required
NO
Remediation required, incident to be disclosed to the AER

Figure 5.1 Field QA/QC verification program

6 Storage of Drilling Waste

6.1 Introduction

Drilling waste can be stored on the well site where it was generated or on a remote site. The systems typically used to store drilling waste are

- sumps, which are earthen excavations;
- alternative storage systems, which are aboveground tanks or other storage vessels, sumps lined with a synthetic liner, or other storage systems approved by the AER; and
- earthen-bermed storage systems, which are earthen structures built on grade.

6.2 General Drilling Waste Storage Requirements

1) Licensees must only put drilling waste in a drilling waste storage system. It is prohibited to mix camp sewage or other oilfield wastes (e.g., produced fluids, completion fluids, workover fluids, or spill material) with the drilling waste. It may be appropriate to direct rig washwater to a drilling waste storage system provided only water-based drilling wastes are stored in it and only freshwater is used to wash the rig; this activity needs to be considered when assessing the drilling waste as it could be a source of toxicity.

2) Licensees must only use a storage system to store drilling wastes.

   Note: Licensees may (notwithstanding requirement 2) treat the drilling waste in a storage system to adjust pH, facilitate solids and liquids separation, or reduce drilling waste toxicity.

3) Licensees must ensure that drilling waste storage areas are maintained in a clean condition and that drilling wastes do not create or constitute a safety hazard or nuisance or adversely affect air, soil, or surface- or groundwater.

4) Licensees must secure the drilling waste storage system so that it is not a public or wildlife hazard (e.g., implement measures to prevent public or wildlife from entering it).

5) Licensees must ensure that only their wells and pipelines contribute drilling waste to their drilling waste storage system.

6) Licensees must ensure that waste from directional drilling for pipeline construction and waste from drilling oil or gas wells are stored and disposed of separately.

7) If wishing to conduct other drilling waste treatment activities in a storage system, licensees must obtain written AER approval as set out in section 19 prior to implementation of the treatment activity.

8) Licensees must locate the storage system or implement measures (e.g., site contouring, berms) to prevent the entrance of surface run-on/run-off waters. Precipitation landing within the storage system must be managed as drilling waste.

9) Licensees must ensure the exterior walls of drilling waste storage system are at least

   a) 20 m from an on-site rig water well,

   b) 50 m from any off-site water well, and

   c) 100 m from a water body.

   Note: Licensees may (notwithstanding requirement 9[c]) locate the drilling waste storage systems within a minimum distance of 50 m of a water body if either the

   - water body is upgradient of the drilling waste storage system, or
   - landscape creates a physical barrier that would prevent the migration of drilling waste towards the water body.

10) Licensees must maintain a minimum freeboard of 0.5 m on all drilling waste storage systems. Seasonal precipitation rates, in addition to the volume of the expected drilling waste, must be considered when determining storage system capacities.

11) Within 18 months of rig release of the first well that contributed drilling waste to the storage system, licensees must

   a) remove the drilling waste from the storage system and manage it following the requirements of this directive, and

   b) physically close the storage system.

      Physical closure includes dismantling the storage system, decontaminating (if needed) the area beneath and surrounding it and, if applicable, backfilling/contouring the area used for the storage system. The objective is to close the storage system in a manner that will allow the site to be restored to equivalent land capability.

6.3 Sump Construction Requirements

12) Licensee must only construct a sump(s) on a site with appropriate deposits of clayey soils (i.e., meets the criteria set out in requirement 13[b] below) that are free of hydraulic defects such as gravel lenses, silt lenses, sand lenses, cracks, fissures, and root channels.

(13) Licensees must have a qualified person conduct a site investigation to delineate the in situ clayey deposits. The site investigation must consist of

a) a minimum of three boreholes, arranged in an approximate equilateral triangle, to establish the orientation of any significant geological plane. Sufficient lithology data (boreholes) must also be gathered to confirm that the deposit of appropriate clayey material extends a minimum of 1 m beyond the horizontal and vertical dimensions of the sump.

b) a representative soil sample from each of the three boreholes analyzed in a lab to confirm that the clay deposit has the following characteristics:

i) greater than 50 per cent (mass calculated as dry weight percentage passing a no. 200 sieve),

ii) greater than 20 per cent clay (i.e., 0.002 millimetre [mm]) or smaller as determined by the hydrometer method),

iii) a liquid limit (LL) equal to or greater than 30 per cent, and

iv) a plasticity index (PI) equal to or greater than 15 per cent.

c) for sumps of an area of 100 m^2 or less (roughly 10 m × 10 m or less), the lab analysis required in (b) above can be reduced to one sample provided the three cores from the boreholes required in (a) above are similar in texture (i.e., hand texture method) and appearance, indicating limited variability for the characteristics set out in (b) above.

Note: Reduction of lab analysis described in (c) does not apply to sites with more than one sump.

(14) Before constructing the sump, licensees must prepare the site following typical well site and well construction practices. During sump construction it is important to determine whether naturally saline subsoils are being encountered. In situations where this occurs, care must be taken to appropriately stockpile these soils and replace them at an appropriate depth so that at the time of final reclamation the site can be restored to equivalent land capability.

6.4 Remote Drilling Waste Storage Requirements

A remote drilling waste storage site is a drilling waste storage system that is either

- located on a standalone site, or
- located on a well site that is receiving drilling waste from more than one well.

Note that licensees intending to recycle/reuse drilling waste (i.e. drill cuttings) or subsequent to/if can temporarily store the drilling waste on the subsequent to/if site without designating it a waste storage site provided the subsequent to/if site holds an SWR to/if licence, the drilling waste is stored in aboveground tanks, and the storage duration does not exceed three months, in accordance with section 3.7 of Directive 055: Storage Requirements for the Upstream Petroleum Industry.

The following requirements are additional to the requirements specific to the type of drilling waste storage system being used:

(1) Licensees must ensure that only wells for which they are the licensee contribute drilling waste to drilling waste storage systems on a common site.

(2) If the remote drilling waste storage system is located on a site other than a licensed to/if site, licensee must obtain a written agreement from the landowner or department agency managing the land on behalf of the provincial or federal Crown (e.g., a surface lease or right-of-entry agreement or a disposition under the *Public Lands Act*).

(3) If the remote drilling waste storage system is located on a site other than a licensed to/if site, licensee must have signage at the site (electronic identifying the legal subdivision (LSD), the licensee, the to/if licence or wells the site is linked) (see requirement 3.7 bullet c), and a 24-hour emergency phone number. The site must be secured or that it is not publicly hazard (e.g., fence the sump or implement other measures to prevent the public or animals from entering it).

(4) For liability tracking purposes, licensee must be liable (i.e., link) the remote drilling waste storage site to the to/if licence that generated the drilling waste. In situations where more than one to/if contributes drilling waste to the remote drilling waste storage system, licensee must be liable (i.e., link) the remote drilling waste storage site to the licence of the to/if that first contributed drilling waste.

Refer to section 4.3 for the remote site marking requirements for pipeline-generated drilling waste.

6.3 Earthen-lined Storage System Requirements

(1) Licensees must only use earthen-lined storage systems

a) to store water-based/synthetic-based drilling waste solids (i.e., cuttings) intended to be landspread or managed at an approved waste management facility, and

b) on a to/if site or remote drilling waste storage site that has been prepared following typical to/if site and soil conservation practices (i.e., topsoil removed and conserved).

[illegible] A [illegible] must assess the [illegible] [illegible] of [illegible] to which the [illegible] [illegible] system is to be constructed and verify the [illegible] use of [illegible] [illegible]. The assessment must consist of the following:

a) At a minimum, three [illegible] samples must be taken from the area in which the [illegible] storage system will be constructed. Each sample must be [illegible] to confirm that for a minimum depth of [illegible] m, the soil [illegible] the [illegible] of the [illegible] has the following characteristics:

i) greater than [illegible] per cent [illegible] [illegible] by weight passing [illegible] sieve; and

ii) greater than [illegible] per cent clay [illegible] as determined by the [illegible] [illegible];

[illegible] A [illegible] must [illegible] the [illegible] [illegible] [illegible]

[illegible]

9 Management of Cement Returns

9.1 Introduction

In some situations, cement returns are not isolated from the drilling waste and get placed in the [illegible] provided all of the requirements for mix-bury-cover are met.

During the storage of cement returns, water may collect within the storage system. Licensees may use the pump-off method to remove the collected water given that all requirements under section 12 are followed.

9.2 Requirements

1) Licensees must use one of the following options to manage cement returns that have been isolated from the drilling waste:

   a) Allow the isolated cement returns to harden in aboveground synthetically lined walled storage systems (AWSS) which are often called cement cups. The following requirements must be met when using AWSS for storage of cement returns:

      i) the capacity must not exceed 50 m^3;

      ii) the synthetic liner must be at least 12 mil thick, have properties (i.e., density, tensile strength, elongation, tear resistance, and puncture resistance) suitable for the intended use, be chemically resistant to the compounds used to formulate the cement, and be rated for the temperatures encountered (i.e., the temperature of the cement returns and the ambient temperature); the manufacturer's liner specifications must be documented;

      iii) the wall system must be engineered to withstand the hydraulic pressure of the stored contents at full capacity;

      iv) the liner must cover the ground floor of the walled system, extend up the wall and be fastened onto the outside of the wall;

      v) the system used to fasten the liner must secure the liner to the wall system but must not damage the liner;

      vi) the storage duration must not exceed one year; within the one-year timeframe, the cement returns must be removed and the AWSS must be dismantled;

viii) the removed, hardened cement returns must be broken into pieces 0.5 m^3 or less in size and placed into pits meeting requirement (c) below, or be managed in accordance with requirements (d) or (e) below; and

viii) liners must not be reused and must be managed as an oilfield waste in accordance with *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*.

b) Allow the isolated cement returns to harden in aboveground portable rigid structures that will adequately contain the cement returns and prevent releases into the environment. The following requirements must be met when using portable structures for storage of cement returns:

i) the structures must be able to withstand the hydrostatic pressure of the stored contents at full capacity;

ii) the storage duration must not exceed one year; within the one-year timeframe, the cement returns must be removed from the portable structure; and

iii) the removed, hardened cement returns must be broken into pieces 0.5 m^3 or less in size and placed into pits meeting requirement (c) below, or be managed in accordance with requirements (d) or (e) below.

c) Place the isolated cement returns into a segregated pit (or pits) on the originating well site or associated remote drilling waste storage site, allow the cement to harden, break the cement into pieces 0.5 m^3 or less in size, and cover the pieces with at least 1 m of clean fill. In addition,

i) written landowner consent must be obtained before placing cement returns into the pit(s) in situations where one pit or the collective area of more than one pit exceeds 4 m^2;

ii) the pit(s) must not be constructed in the water table;

iii) the area of one pit, or collective area of more than one pit, on one well site, multiwell site, or remote drilling waste storage site, must not exceed 100 m^2 (i.e., about 10 m by 10 m);

iv) notwithstanding requirement (iii) above, if the wells that generated the cement returns are part of an oil sands development, and the well site, multiwell site, or remote drilling waste storage site on which the cement return pit(s) is located is on

public lands, the area of one pit or collective area of more than one pit must not exceed 900 m^2 (i.e., about 30 m by 30 m);

v) measures must be implemented to prevent the public or animals from entering the pits;

vi) the cement returns must be buried or removed within 18 months of the rig release date of the first well that contributed cement returns to the cement pits;

vii) the buried cement returns must not interfere with subsurface water flow and the objective to restore the site to equivalent land capability; and

viii) the buried cement returns must be disclosed during the reclamation process for the well site or remote drilling waste storage site.

d) Place cement returns that are either isolated from drilling waste or removed from a cement return storage pit into cells that are part of an approved landfill; landfills established on AER-regulated upstream petroleum sites are subject to the application and approval process set out in *Directive 058*; all other landfills in Alberta are subject to the application and approval process prescribed by *EPEA*.

Cement return storage pits may be reused provided conditions (i)–(vi) in (c) are met.

e) Apply to the AER for approval to manage or recycle the cement returns in an alternative manner (see section 19).

8 Drilling Wastes from Pipelines

8.1 Introduction

Directional drilling for the purpose of pipeline construction is often practised by the oil and gas industry as a method for mitigating environmental impacts. As such, the toxicity of the drilling mud, the impact of drilling mud releases on water quality or infrastructure, and methods of drilling waste storage and disposal must be considered before beginning the directional drilling.

Note that *CSA Z662-11: Oil and Gas Pipeline Systems*, contains a number of requirements pertaining to horizontal drilling of pipeline crossings, including the need for a drilling execution plan (which includes drilling fluid management), personnel training, and pipe handling. These requirements are mandatory for installation of pipeline in Alberta in accordance with the Alberta *Pipeline Rules*.

The requirements set out in this section pertain to the storage and disposal of drilling waste from directional drilling activities for pipeline construction.

8.2 Requirements

1) Licensees must evaluate the toxicity of additives, products, and chemicals added to the drilling mud system to verify that all are used in concentrations below the accepted pass threshold for the luminescent bacteria toxicity test (EC50[15] ≥75 per cent). Refer to section 4.3 for more information on drilling waste assessment.

   Drilling mud systems composed solely of fresh water and bentonite do not require toxicity evaluations. In addition, field screening for pH, EC, SAR, (magnesium [Mg], sodium [Na], calcium [Ca]), and nitrogen (NH_3-N, NO_3-N, NO_2-N) is acceptable for all disposal methods. All other requirements of *Directive 050* must be met.

2) If the toxicity is not known for any of the additives, products, or chemicals, licensees must

   a) develop a generic mud system that mimics the mud formulation that will be used for the drilling program (it must contain the highest concentration of individual mud products/fluid additives that would be used in the mud system) and test it for metals (refer to table 3.4), toxicity (luminescent bacteria), and salinity (EC, SAR, Na, N) (refer to section 4.4); and

   b) only use the mud system for drilling if the generic mud system passes the luminescent bacteria toxicity test; use the metal and salinity information to make decisions about potential drilling waste disposal methods and meet requirements for the disposal methods that are actually used.

3) Licensees must appropriately store drilling muds and wastes at the entry and exit points of the drilling activity. Acceptable storage systems include

   a) earthen pits that are constructed in clayey soils that contain at least 20 per cent clay and 50 per cent fines and extend at least 1 m beyond the bottom and sides of the pit;

   b) tanks, conductor barrels, or lined earthen pits; or

   c) earthen pits not meeting the criteria specified in (a) above, provided the drilling mud/waste released into the pit is immediately and continually removed during the drilling activity and stored/managed in accordance with this directive.

4) Immediately upon completion of drilling, licensees must remove the drilling waste from the pits and manage it in accordance with the methods set out in this directive, then backfill/reclaim the pits.

   Licensees are to ensure that mix-bury-cover and landspreading disposal methods are limited to an area of a pipeline right-of-way that has a disturbed surface (e.g., topsoil has been removed, right-of-way is under construction or has been disturbed for pipeline work) or to a remote site that meets requirement 5 below. Disposal of drilling waste on a pipeline right-of-way is limited to waste generated from construction of the pipeline associated with the right-of-way.

   Landowner consent is not required when the disposal of drilling waste occurs on a pipeline right-of-way that has a disturbed surface. Landowner/department/agency consent is required prior to conducting landspray, landspray-while-drilling, or pump-off disposals when the surface of the pipeline right-of-way is restored and is being used by the landowner/department/agency.

   Additional land used for drilling waste management that is not part of the pipeline right-of-way is considered to be a remote site. This includes land that is used as temporary work space.

5) Licensees using a remote site must

   a) have a written agreement specifically for drilling waste management from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (e.g., a surface lease or right-of-entry agreement, or disposition under the *Public Lands Act*) as set out in section 1.6 of this directive;

   b) meet the storage requirements set out in sections 6.2, 6.3, and 6.4 of this directive;

   c) tie back (i.e., link) the remote site to the licence and line number of the pipeline that generated the drilling waste and meet applicable reclamation obligations for the site as described in section 1.6 of this directive; and

d) within one year of the first receipt of drilling waste into the storage system

   i) remove the drilling waste and manage it in accordance with the methods set out in this directive, and

   ii) physically close the storage system.

   Physical closure includes dismantling the storage system, decontaminating (if needed) the area beneath and surrounding it and, if applicable, backfilling/contouring the area used for the storage system. The objective is to close a storage system in a manner that will allow the site to be restored to equivalent land capability.

6) For drilling waste that has been generated from directional drilling activities, licensees must document the following information and retain it until the pipeline has been abandoned. If a remote site was used to manage the drilling waste, licensees must document the following information and retain it until the remote site has been successfully reclaimed (e.g., a reclamation certificate for sites designated as specified lands or alternative documentation from the department/agency responsible for nonspecified lands):

   a) the pipeline segment (licence and line number) that generated the drilling waste;

   b) the pipeline "from" and "to" location (i.e., the LSD);

   c) the legal land location (the LSD), the plot plan showing the entry and exit pits of the directional drill, and a description of the method used to prevent migration of drilling mud/waste during drilling (e.g., tanks, liners, conductor barrels) in the event that the pit does not consist of suitable clayey soils;

   d) if a remote site was used, its LSD and specific use (e.g., storage, including type of storage system, and disposal, including type of disposal method), and a plot plan showing the storage and disposal areas;

   e) the type of mud system used and a list of all of the additives, products, or chemicals used, including the volume used, and documentation to verify the mud system was nontoxic (refer to requirements 1 and 2 above);

   f) the volume of drilling waste generated and the management method used, including documentation to demonstrate compliance with the requirements for the selected method;

   g) proof of landowner/department/agency consent or agreement, including a "plan of survey" of the disposal site(s); and

   h) a copy of the completed form from requirement 7 below.

7) Licensees must electronically submit post-disposal information identifying the drilling waste volumes generated, storage systems used, disposal methods used, and locations of disposals. Within 12 months of each directional drilling activity, licensees must fill out and submit a Directive 050: Drilling Waste Pipeline Disposal Form through the Digital Data Submission (DDS) system on the AER website at www.aer.ca. The Drilling Waste Pipeline Disposal Form is located in the DDS system under AER > Submissions > Drilling Waste Data; select Pipeline Disposal as the Submission Type.

Authorized AER customers require a login ID and password to access the DDS system. For help getting a login ID, contact your company's AER DDS administrator. If you are unable to contact your company's AER DDS administrator, contact DDSAdminstrator@aer.ca.

9 Landspray

9.1 Introduction

The landspray disposal method involves spraying fluid or total waste onto topsoil and may or may not involve incorporating the waste into the soil. Incorporation is typically done when the drilling waste has been landsprayed on cultivated land. It is accomplished by mechanically combining the drilling waste into a homogeneous soil/waste mix. Drilling waste that has been landsprayed on vegetated land is typically not incorporated. A calculated loading rate or maximum application rate is used to determine the area required for landspraying.

Vegetated lands include grasslands, native prairie, and forage lands, but not forested public lands. Refer to section 11 for requirements that are specific to disposal on forested public lands.

While landspray is typically conducted outside of the lease boundaries of a well site or remote drilling waste storage site, this does not preclude conducting landspray operations on the well site that generated the drilling waste or on a remote site, provided the drilling waste was stored on the remote site. Landspray may also be used on well site access roads provided these locations are leased or owned by the well licensee and landowner/department/agency written consent has been obtained. Landspray disposal on pipeline rights-of-way is limited to drilling waste resulting from directional drilling for construction of the pipeline associated with the pipeline right-of-way.

Note: It is not permissible for a licensee to use the landspray disposal method for hydrocarbon-based drilling wastes.

Refer to table 9.1 for a summary of the requirements for the landspray disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

9.2 Landspray Receiving Soil Requirements

1) Licensees must only select land for the landspray disposal method that

   a) has a slope of less than 5 per cent for summer (unfrozen ground) operations or a slope of less than 3 per cent for winter (frozen and snow covered) operations,

   b) is not within 10 m of a road ditch or property line,

   c) is not within 100 m of a water body, and

   d) is not within 50 m of a water well.

Note: Licensees may (notwithstanding requirement 1[a][i]) reduce the water body separation distance to 50 m if the water body is upgradient of the selected disposal area or if the landscape creates a physical barrier that would prevent the drilling waste from migrating towards the water body.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) Select one sampling site for every 4 ha of a disposal area.

   b) Ensure each sampling site is a circular area with a 10 m radius and a centre precisely located and documented by GPS using the Universal Transverse Mercator (UTM) coordinate system, along with bearing and metres from a fixed point.

   c) At a minimum, collect one composite sample for the 0 to 10 cm soil depth increment from each sampling site. For landspray without soil incorporation, take the sample from the soil profile beneath the leaf litter layer, if present. Each composite sample must comprise five subsamples.

3) Licensees must assess the receiving soil as set out in section 3 to confirm its suitability for the landspray disposal method.

4) Licensees must (except when the disposal is occurring on a well site, remote drilling waste storage site, or an area of a pipeline right-of-way that has a disturbed surface) obtain written consent from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to section 1.5) before beginning any landspray activities.

9.3 Landspray Disposal Requirements

5) Licensees must segregate cement returns from the drilling waste and manage them as set out in section 7.

6) If solids and cuttings are separated from the drilling waste, licensees must manage the separated solids and cuttings by a different method (e.g., mix-bury-cover, landspreading, biodegradation) or, alternatively, send them to an approved waste management facility.

   If the drilling waste was originally analyzed as a total waste and the volume of the separated solids and cuttings is less than 20 m³, additional analysis is not required unless further information is needed to meet the requirements of the other disposal method.

7) Licensees must contain the drilling waste in a storage system prior to landspreading, and

a) take a fluids sample to determine the suitability of the method, if only the fluids are to be landspread and the solids are to be managed by another option, or
landspread and the solids are to be managed by another option, or

b) take a total waste sample to determine the suitability of the method, if the fluid and solid phases are to be landspread together.

8) Licensees must analyze the drilling waste sample for the parameters listed below and use the results to determine spread rates that will prevent the receiving soil from exceeding the soil endpoints for salts, hydrocarbons, and metals set out in section 3:

a) pH, EC, SAR, sodium (Na), and toxicity;

b) nitrogen (N), if the cumulative amount of N (NH_4-N, NO_3-N, NO_2-N) in additives/products added to the drilling mud or waste system exceeds 100 kg or is unknown;

c) metals, if cumulative concentrations of metals in mud additives/products added to the drilling mud system exceed the concentrations set out in table 3.4 or are unknown; and

d) hydrocarbons, if a hydrocarbon flag is present.

9) Licensees must ensure that

a) the pH of the drilling waste is not less than 6 or greater than 10.5;

b) the drilling waste passes a toxicity test. for those drilling wastes that only pass the toxicity test after being charcoal treated, disposal may only proceed if hydrocarbons are the likely source of toxicity (refer to section 4.3);

c) the maximum drilling waste spread rate is not less than 10 m^3/ha (note: that the calculated spread rate for a parameter decreases as the concentration of the parameter in the drilling waste increases);

d) the maximum drilling waste spread rate does not exceed 40 m^3/ha for summer (unfrozen ground) operations;

e) the maximum drilling waste spread rate does not exceed 20 m^3/ha for winter operations, which are in effect when the soil is saturated with water, icy (wetted), snow covered, or frozen. spread rates for winter operations must be determined using calculations for application "without soil incorporation."

(f) an earlier application where the disposal area is more extended, the disposal area is proposed so that the drilling waste is applied to the surface of the disposal area and not onto more accumulations
accumulations

(g) the drilling waste does not change or pond on the land, migrate off the disposal area, or cause land erosion.

Note: To avoid physical issues such as ponding, erosion, or waste migration, the maximum summer and winter application rates are the "annual maximum gross rates" that can be applied to the disposal area.

(h) the sodium application rate does not exceed 210 kg/ha and the nitrogen application rate does not exceed 25 kg/ha; and

(i) the whole application rate does not exceed 4 tonne dry/ha when growing new vegetated bands, and the landowner does not sanction or direct the vegetation (i.e., changing or one-off application resulting in vegetation being created with drilling waste)

(10) Licensees wishing to exceed the nitrogen application rate of 25 kg/ha must submit an application and obtain NZPI approval for an alternative management method as set out in section 19 of this document; information listed in section 10.1 of appendix 1 must be provided to support the application.

(11) If the waste is treated (e.g., pH adjusted, hydrocarbons removed), licensees must have the waste resampled and retested and re-determine its suitability for a landspray disposal method.

(12) If spread rates were determined by the calculations for "soil incorporation," licensees must ensure that the drilling waste is incorporated into the receiving soil at a minimum depth of 15 cm within 48 days of disposal. If incorporation is not done right after application, licensees must select sites where it is reasonably clear vegetation of drilling waste from the application area would not occur within the 48 days allowed for incorporation; otherwise, licensees must use spread rates calculated for applications without soil incorporation.

(13) If landspraying is to be done without soil incorporation, licensees must determine spread rates using the calculations for "no soil incorporation."

(14) Licensees must discuss companion and access control landings with the landowner/department agency prior to disposal to ensure that both parties have understood each other's expectations.

[illegible]

6.6 Landspreading / Post-disposal Requirements

(1) A licensee must conduct post-disposal sampling, within 24 days of the disposal date and finally disposal, after completing the disposal and, compare the results to the applicable soil contaminant disposal, after completing the disposal and compare the results to the applicable soil subgrade soil and at section 7.3 of the following criteria are met:

(a) If the GC of the drilling waste exceeds 10 mg/kg, the nitrogen loading rate exceeds 210 kg/ha or the sodium loading rate exceeds 210 kg/ha, then apply to the GC, SAR, Na, and EC(1:2) to 100, 15, 100, 15;

(b) If the concentration of metals in the drilling waste exceeds any of those set out in table 7.5 or 7.6, then apply to the metals;

(c) If a hydrocarbon flag was associated with the hydrocarbon concentration in the drilling waste exceeds the values for any of the parameters set out in table 7.1, then apply to the hydrocarbons.

Table 3.2 Summary of the Nuclear Regulatory Commission

Pre-application considerations	Initial application requirements	Post-application considerations	Licensing requirements
Physical security	Financial qualifications	Construction of a design or a combined construction and operating license application	Physical security
Applicant identity and business structure	Decommissioning funding plan	Application for a design or a combined construction and operating license application	Site suitability
Site suitability	Application content requirements	Mandatory hearing	Emergency preparedness
Major environmental issues identified in the National Environmental Policy Act process	Application content requirements for a combined construction and operating license application	Site inspection	Applicant technical qualifications
Site boundary	Application content requirements for a standard design certification	Environmental review	Applicant financial qualifications
Site exclusion area	Application content requirements for an early site permit	Safety review	Environmental review
Low-population zone	Environmental report	Construction inspection, testing, analysis, and acceptance criteria	Safety review
Population density	Environmental review	Operational program review	Mandatory hearing
Physical characteristics unique to the proposed site	Safety review	Emergency planning inspection, testing, analysis, and acceptance criteria	Combined construction and operating license
Proximity to dams	Emergency preparedness review	Environmental review	Inspection, testing, analysis, and acceptance criteria
Proximity to military and chemical installations	Technical qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Operational program review
Regional demography, land use, and water features	Financial qualifications review	Emergency planning inspection, testing, analysis, and acceptance criteria	Environmental review
Regional meteorology	Decommissioning funding plan review	Environmental review	Safety review
Flood, tsunami, and seiche potential	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Transportation routes near the site	Safety review	Environmental review	Limited work authorization
Seismology	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Surface faulting	Technical qualifications review	Environmental review	Limited work authorization
Nearby industrial, transportation, and military facilities	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Offsite hazards	Decommissioning funding plan review	Environmental review	Safety review
Meteorology	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Hydrology	Safety review	Environmental review	Limited work authorization
Geology	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Seismology	Technical qualifications review	Environmental review	Safety review
Surface faulting	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Nearby industrial, transportation, and military facilities	Decommissioning funding plan review	Environmental review	Limited work authorization
Offsite hazards	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Meteorology	Safety review	Environmental review	Safety review
Hydrology	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Geology	Technical qualifications review	Environmental review	Limited work authorization
Seismology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Surface faulting	Decommissioning funding plan review	Environmental review	Safety review
Nearby industrial, transportation, and military facilities	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Offsite hazards	Safety review	Environmental review	Limited work authorization
Meteorology	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Hydrology	Technical qualifications review	Environmental review	Safety review
Geology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Seismology	Decommissioning funding plan review	Environmental review	Limited work authorization
Surface faulting	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Nearby industrial, transportation, and military facilities	Safety review	Environmental review	Safety review
Offsite hazards	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Meteorology	Technical qualifications review	Environmental review	Limited work authorization
Hydrology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Geology	Decommissioning funding plan review	Environmental review	Safety review
Seismology	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Surface faulting	Safety review	Environmental review	Limited work authorization
Nearby industrial, transportation, and military facilities	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Offsite hazards	Technical qualifications review	Environmental review	Safety review
Meteorology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
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Geology	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
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Surface faulting	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Nearby industrial, transportation, and military facilities	Technical qualifications review	Environmental review	Limited work authorization
Offsite hazards	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Meteorology	Decommissioning funding plan review	Environmental review	Safety review
Hydrology	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Geology	Safety review	Environmental review	Limited work authorization
Seismology	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Surface faulting	Technical qualifications review	Environmental review	Safety review
Nearby industrial, transportation, and military facilities	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Offsite hazards	Decommissioning funding plan review	Environmental review	Limited work authorization
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Nearby industrial, transportation, and military facilities	Decommissioning funding plan review	Environmental review	Safety review
Offsite hazards	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Meteorology	Safety review	Environmental review	Limited work authorization
Hydrology	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Geology	Technical qualifications review	Environmental review	Safety review
Seismology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Surface faulting	Decommissioning funding plan review	Environmental review	Limited work authorization
Nearby industrial, transportation, and military facilities	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Offsite hazards	Safety review	Environmental review	Safety review
Meteorology	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Hydrology	Technical qualifications review	Environmental review	Limited work authorization
Geology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
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Surface faulting	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Nearby industrial, transportation, and military facilities	Safety review	Environmental review	Limited work authorization
Offsite hazards	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Meteorology	Technical qualifications review	Environmental review	Safety review
Hydrology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Geology	Decommissioning funding plan review	Environmental review	Limited work authorization
Seismology	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Surface faulting	Safety review	Environmental review	Safety review
Nearby industrial, transportation, and military facilities	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Offsite hazards	Technical qualifications review	Environmental review	Limited work authorization
Meteorology	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Hydrology	Decommissioning funding plan review	Environmental review	Safety review
Geology	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Seismology	Safety review	Environmental review	Limited work authorization
Surface faulting	Emergency preparedness review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Nearby industrial, transportation, and military facilities	Technical qualifications review	Environmental review	Safety review
Offsite hazards	Financial qualifications review	Operational program inspection, testing, analysis, and acceptance criteria	Mandatory hearing
Meteorology	Decommissioning funding plan review	Environmental review	Limited work authorization
Hydrology	Environmental review	Operational program inspection, testing, analysis, and acceptance criteria	Environmental review
Geology	Safety review	Environmental review	Safety review

10 Landspray Waste Drilling

10.1 Introduction

The landspray waste drilling (LWD) disposal method involves spraying drilling waste onto topsoil at controlled, low application rates. LWD is limited to drilling wastes from water-based drilling mud systems, which are shown to be nontoxic using the luminescent bacteria toxicity test.

The landspray and LWD disposal requirements are similar, but as the LWD method is limited to only nontoxic mud systems, the testing requirements have been reduced, and disposal is allowed to proceed without first storing the drilling waste (e.g., by sumpless drilling). The controlled application is normally conducted during the drilling operation. Spraying techniques may include the use of vacuum trucks or similar equipment.

Although incorporation of the drilling waste into the receiving soil is at the discretion of the landowner, the intent of this disposal method is to meet all applicable endpoints without the need for incorporation. Should incorporation be necessary to meet endpoints, then the landspray disposal method must be used, with all applicable criteria.

While LWD is typically conducted outside of the lease boundaries of a well site or remote drilling waste storage site, this does not preclude conducting the LWD operations on the well site that generated the drilling waste. Small volumes of fluids may be landsprayed on access roads to the well site provided these locations are leased or owned by the licensee and landowner/department/agency written consent has been obtained. LWD disposal on pipeline rights-of-way is limited to drilling wastes resulting from directional drilling for construction of the pipeline associated with the pipeline right-of-way.

Refer to table 10.1 for a summary of the requirements for the LWD disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

10.2 Landspray Waste Drilling Receiving Soil Requirements

1) Licensees must only select land for the LWD disposal method that

   a) has a slope of less than 7 per cent for summer (unfrozen ground) operations or a slope of less than 1 per cent for winter (frozen and snow covered) operations,

   b) is not within 10 m of a road ditch or property line,

c) is not within 100 m of a water body, and

d) is not within 50 m of a water well.

Note: Licensees may (notwithstanding requirement 1[c]) reduce the water body separation distance to 50 m if the water body is upgradient of the selected disposal area or if the landscape creates a physical barrier that would prevent the drilling waste from migrating towards the water body.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

a) Select one sampling site for every 4 ha of a disposal area.

b) Ensure each sampling site is a circular area with a 10 m radius and a centre precisely located and documented by GPS using the Universal Transverse Mercator (UTM) coordinate system, along with bearing and metres from a fixed point.

c) At a minimum collect one composite sample for the 0 to 10 centimetre (cm) soil depth increment from each sampling site. Take the sample from the soil profile beneath the leaf litter layer, if present. Each composite sample must comprise five subsamples.

3) Licensees must assess the receiving soil as set out in section 3 to confirm its suitability for the LWD disposal method.

4) Licensees must (except when the disposal is occurring on a well site, remote storage site, or an area of a pipeline right-of-way that has a disturbed surface) obtain written consent from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to section 1.5) before beginning any landspray activities.

10.2 Landspray-While-Drilling Disposal Requirements

5) Licensees must segregate cement returns from the drilling waste and manage them as set out in section 7.

6) Licensees must isolate drilling test fluids and any sections of the mud system that are contaminated by hydrocarbons and manage them by a different method.

7) If solids and cuttings are separated from the drilling waste, licensees must manage the separated solids and cuttings by a different method (e.g., mix-bury-cover, landspreading, biodegradation) or, alternatively, send them to an approved waste management facility. If the drilling waste was originally analyzed as a total waste and the volume of the separated solids and cuttings is less

than 20 m^3, additional analysis is not required unless further information is needed to meet the requirements of the other disposal method.

8) Licensees must sample and analyze the drilling waste for pH, EC, SAR, Na, and N (if the cumulative amount of N [NH_3-N, NO_3-N, NO_2-N] in additives/products added to the drilling mud or waste system exceeds 100 kg or is unknown) and use the results to determine spread rates that will prevent the receiving soil from exceeding the soil endpoints set out in section 3.

9) Licensees must only use the LWD disposal method for water-based drilling mud systems where the resulting drilling waste (fluids or total waste)

   a) has a pH within the range of 6 to 10.5;

   b) has an EC that does not exceed 16 dS/m;

   c) contains no visible hydrocarbons, and no other hydrocarbon flags were encountered while the well was drilled;

   d) does not contain cumulative concentrations of metals from mud additives/products that exceed the values set out in table 3.4 (another disposal option must be used if metal content is unknown); and

   e) does not contain any mud additives/products that were used in concentrations above the luminescent bacteria toxicity test pass threshold (EC50[15] ≥75 per cent) (another disposal option must be used if the toxicity of any of the mud additives/products is unknown).

Note: Licensees can compensate for points (d) and (e) above by following the "generic mud system" protocol as set out in section 4.3(10).

10) Licensees must ensure that

   a) the minimum drilling waste spread rate is not less than 10 m^3/ha (note that the calculated spread rate for a parameter decreases as the concentration of the parameter in the drilling waste increases);

   b) the maximum drilling waste spread rate does not exceed 40 m^3/ha for summer (unfrozen ground) operations;

   c) the maximum drilling waste spread rate does not exceed 20 m^3/ha for winter operations, which are in effect when the soil is saturated with water, ice covered, snow covered, or frozen;

   d) spread rates are determined using calculations for application "without soil incorporation";

e) in winter operations when the disposal area is snow covered, the disposal area is prepared so that the drilling waste is applied to the surface of the disposal area and not onto snow accumulation;

f) the drilling waste does not clump or pool on the land, migrate off the disposal area, or cause land erosion;

Note: To avoid physical issues such as pooling, erosion, or waste migration, the maximum summer and winter application rates are the "actual maximum spray rates" that can be applied to the disposal area.

g) the sodium application rate does not exceed 250 kg/ha, and the nitrogen application rate does not exceed 25 kg/ha; and

h) the solids application rate does not exceed 6 t/ha when spraying onto vegetated lands, and the landspray does not smother or stress the vegetation (i.e., clumping or uneven application resulting in vegetation being coated with drilling waste).

11) If wishing to exceed the nitrogen application rate of 25 kg/ha, licensees must use another disposal method (e.g., landspray) and obtain AER approval for an alternative management method as set out in section 19 of this directive; information based on section A2.3 of appendix 2 must be provided to support the application.

12) Licensees must separate and handle drilling wastes as different sections of the well are drilled (e.g., top, middle, and bottomhole) if changes are made to the drilling mud formulation for the different well sections and it cannot be confirmed that the conditions of requirements 9 and 10 above will continue to be met.

13) Licensees must ensure that LWD disposal operations occur within 48 hours of rig release. Under extreme weather conditions, drilling waste can be stored in tanks for a maximum of 96 hours after the rig has been released, but the drilling waste must be retested before beginning the LWD operations. An alternative management option must be used if this timeline cannot be achieved.

14) Licensees must discuss compaction and access impact (rutting) with the landowner/department/agency prior to disposal to ensure that both parties have understood each other's expectations.

10.4 Landspray-While-Drilling Post-disposal Requirements

15) Licensees must conduct post-disposal sampling of the waste/soil mix within 60 days of the disposal (but preferably directly after) and compare the results to the applicable soil endpoints set out in section 3 if any of the following criteria are met:

a) If the EC of the drilling waste exceeds 10 dS/m, then analyze for EC and SAR.

b) If the nitrogen loading rate exceeds 20 kg/ha, then analyze for N (NH_3-N, NO_3-N, NO_2-N).

c) If the sodium loading rate exceeds 150 kg/ha, then analyze for EC, SAR, and Na.

Table 10.1 Summary of landspray-while-drilling disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving soil • topsoil with EC <2 dS/m, SAR <4 Site • slope must be less than 5% for summer operations and less than 3% for winter operations • 50 m setback from a water well • 100 m setback from a water body • 10 m setback from a road ditch or property line • landowner or Crown department/agency consent for disposa[1] Waste • limited to nontoxic, water-based drilling wastes where no hydrocarbon flags were encountered • segregate cement returns, drillstem fluids, and sections of the mud system contaminated with hydrocarbons • separated solids or drill cuttings must be managed by mix-bury-cover or landspreading or sent to a waste facility for disposal	Fluids or total waste • pH between 6 and 10.5 • EC ≤16 dS/m • no visible hydrocarbons • cumulative concentration of metals in mud additives/products must not exceed values in table 3.4 • mud additives/products used in concentrations below pass threshold level for luminescent bacteria toxicity test • maximum spread rate of 20 m^3/ha in winter conditions and 40 m^3/ha in summer conditions • maximum solids application rate for vegetated lands: 6 t/ha • minimum spread rate: 10 m^3/ha	Soil/waste mix limited to a maximum increase of one unit beyond background soil EC and SAR, but not to exceed an EC of 2 dS/m or an SAR of 4 Maximum Na loading rate: 250 kg/ha Maximum N loading rate: 25 kg/ha Soil/waste mix must not exceed soil hydrocarbon and metal endpoints in tables 3.2 and 3.4	Receiving soil • EC and SAR Liquids or total waste • pH, EC, SAR, Na • N , if an unknown amount or an amount ≥100 kg N was added to the drilling mud or waste system Waste/soil mix (post-disposal) • EC, if the drilling waste exceeds an EC of 10 dS/m • N, if the N loading rate exceeds 20 kg/ha • EC, SAR, and Na, if the Na loading rate exceeds 150 kg/ha

[1] This table summarizes the LWD requirements, but the details within the numbered requirements of section 10 will be used for assessing compliance with the LWD disposal method.

11 Disposal onto Forested Public Lands

11.1 Introduction

The requirements set out in this section are limited to the application of drilling wastes from nontoxic, water-based mud systems onto forested public lands (also referred to as green areas).

Disposal onto forested public lands (DFPL) is used mainly in the winter where drilling waste fluids or total waste (slurried solids and fluid) are applied to specific types of dispositions issued pursuant to the *Public Lands Act*. The method is suited particularly to drilling wastes from shallow wells and winter-access-only wells and to minimum-ground-disturbance (MGD) winter operations. This method reduces the need to construct sumps, which reduces the need to remove timber to accommodate oil and gas operations. Although similar to LWD with respect to the applicable type of drilling waste and the opportunity to conduct sumpless drilling, this method allows higher drilling waste application rates.

Application methods include applying the drilling waste at a predetermined rate with a vacuum truck, a tornagator, or a wagon equipped with a spray bar or deflector; application with hoses or other similar equipment is not suitable.

This method may be used alone or in combination with other methods, such as mix-bury-cover or landspreading on the well site or a remote sump site under a mineral surface lease.

Refer to table 11.1 for a summary of the requirements for the DFPL disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

11.2 Disposal onto Forested Public Lands Site and Receiving Soil Requirements

1) Licensees must only conduct DFPL on lands for which the AER has issued the following types of dispositions:

   a) mineral surface leases (MSLs), which include well sites, remote sump sites, and some short access roads; and

   b) licences of occupation (LOCs), which include developed and undeveloped roads.

2) Licensees must ensure that the licensee of the well that generated the drilling waste is also the holder of the disposition and obtain written consent from the AER to dispose of drilling waste.

3) Licensees must not conduct the disposal in the ditches of a developed LOC (e.g., where a roadbed has been constructed). Any disposal on an MSL or LOC in an MGD operation, as

identified by the AER, must be restricted to cleared areas. In addition, under winter MGD (frozen) conditions, lands under an LOC (whether developed or not) must be ploughed to create snow windrows, and the waste must be applied in several passes (without exceeding the disposal limit) between the snow windrows.

4) Licensees must not conduct DFPL on

   a) other accesses, seismic lines, or existing clearings and openings on public lands;

   b) areas with a slope greater than 5 per cent;

   c) areas where the applied drilling waste could pond, cause erosion, or migrate into lakes or watercourses (e.g., transported through ditches, ditched roads, or natural drainage channels);

   d) locations within 100 m of a water body, 50 m of a water well, and 10 m of ditches or property lines; and

   e) receiving soils where the depth to the mineral soil horizon is greater than 30 cm or where vegetative indicators (e.g., tamarack, stunted black spruce) indicate unsuitable receiving soils, such as open muskeg.

   Note: Licensees may (notwithstanding requirement 4[d]) reduce the water body separation to 50 m if the water body is upgradient of the selected disposal area or if the landscape creates a physical barrier that would prevent migration of the drilling waste towards the water body.

5) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) Select one sampling site for every 4 ha of a disposal area.

   b) Ensure each sampling site is a circular area with a 10 m radius and a centre precisely located and documented by GPS using the Universal Transverse Mercator (UTM) coordinate system, along with bearing and metres from a fixed point.

   c) At a minimum, collect one composite sample from the 0 to 10 cm soil depth increment from each sampling site. Take the sample from the soil profile beneath the leaf litter layer, if present. Each composite sample must comprise five subsamples.

6) Licensees must assess the receiving soil as set out in section 3 to confirm its suitability for the DFPL disposal method.

11.3 Disposal onto Forested Lands Disposal Requirements

7) Licensees must segregate cement volume from the drilling waste and manage them as set out in section 7.

8) Licensees must isolate diffusion test fluids and any sections of the mud system that are contaminated with hydrocarbons and manage them by a different and appropriate method.

9) Licensees must either manage separated solids and cuttings by a different method (i.e., mixture-onsite landspreading, biodegradation) or send them to an approved waste management facility. If the drilling waste was originally tested as a solid waste and the volume of the separated solids and cuttings is less than 20 m^3, separate analysis is not required unless further information is required to meet the requirements of the other disposal method.

10) Licensees must sample and analyze the drilling waste (i.e., fluids or solid waste) for pH, EC, SAR, Na_2 and % of the cumulative amount of % (NR, N, NR, N, NR, N) in additive/product) added to the drilling mud or waste system exceeds 100 kg or is unknown and use the results to calculate spread rates that will prevent the receiving soil from exceeding the constraints for salts set out in table 7.1.

11) Licensees must only use the (WPP) disposal method for water-based drilling mud systems where the drilling waste (fluids or solid waste):

a) has a pH within the range of 4 to 10.5,

b) has an EC that does not exceed 10 dS/m,

c) contains no visible hydrocarbons, and no other hydrocarbon flags were encountered while the well was drilled,

d) does not contain cumulative concentrations of metals from mud additive/products that exceed the values set out in table 7.4 (another disposal option must be used if metal content is unknown), and

e) does not contain any mud additive/products that were used in concentrations above the luminescent bacteria toxicity test pass threshold (EC 5[0.5] ; ?? ppt v/v).

(2) Notwithstanding the requirements of (1)(c), (d), and (e), licensees must store, sample, and test the drilling waste before proceeding with BMPs if

(a) a hydrocarbon flag was encountered during the drilling of the well,

(b) final additive/mud products were used in concentrations exceeding the maximum [illegible] (see Directive 050 [illegible]), or

(c) the cumulative concentration of metals (contributed by all final additive/mud products in the drilling mud system) exceeds the concentrations set out in table [illegible], or if there is not enough final additive/mud products information to determine the metals concentration in the drilling waste.

Note: Licensees can compensate for (b) and (c) above by following the "generic mud system" protocol set out in section [illegible].

(3) Licensees must ensure that

(a) the successful drilling waste spread rate is not less than [illegible] the basis that the calculated spread rate for a parameter decreases as the concentration of the parameter in the drilling waste increases,

(b) the successful drilling waste spread rate does not exceed [illegible] for the metals or other specified limits, and

(c) the drilling waste does not change or pond on the lands outside of the disposal area, or cause land erosion.

Note: To avoid physical issues such as ponding, erosion, and water migration, the successful application rates are the "actual successful spray rates" that can be applied to the disposal area.

[redacted]

Table 11.1 Summary of Payment and Incentive under Model

Pre-application consultation	Post-application submission	Post-application notification	Pre-application publicity
Planning fee for: • Major development (£5,179 per 0.1 hectare, subject to a maximum fee of £250,000) Other: • Payment for the pre-application service for the LPA to provide advice on the proposed development (£1,115 per meeting) • Major development (£25,000) • Minor development (£1,000) • Other development (£500) • Householder development (£250) • Discharge of condition (£116 per request) • Listed building consent (£1,000 per request) Waiver: • Applicants in receipt of income support, working families tax credit or disabled person's tax credit • Applicants in receipt of a guarantee pension credit • Applications made by a parish council or neighbourhood forum	Fee paid to LPA: • £5,179 per 0.1 hectare, (Max £250,000) • £1,115 (Minor) • £578 (Householder development, consent to display an advertisement, works to a listed building, works to trees subject to tree preservation orders, and works in connection with hedgerows) • £234 (Prior approval, proposed development by electronic communications code operators for the purposes of wireless telegraphy) • £96 (Lawful development certificate) • £462 (Lawful development certificate for proposed use or development) • £1,156 (Change of use of a building to use as one or more separate dwellinghouses, and any associated physical alterations to the building) • £385 (Applications for approval of reserved matters following outline approval, limited to access, appearance, landscaping, layout and scale, and any approval of details, consents or agreements required by a condition or limitation attached to the grant of outline planning permission)	Fee paid to LPA: • £462 (Application for a change of use of land or building for the purpose of one dwellinghouse, and any associated physical alterations to the building) Payment to the landowner: £5,000 Payment to Consultee: £1,000 Percentage of the fee paid to the LPA to be paid to the consultee (Minor £1,156 and Major £5,179)	Planning fee for: • £0 (no fee) Publicity costs paid: • £0 (no cost) • £1,000 (Standard payment for site notice, press notice and neighbour letters) • £1,000 – £5,000 (Subject to cost evidence) • £500 (Minor – Publication of press notice only) • £1,000 – £5,000 (Major – Publication of press notice, site notice and neighbour letters, subject to cost evidence) Payment to a consultancy: • £0 – £500 (Subject to cost evidence for the publication of press notice, site notice and neighbour letters, and the consultancy's time spent on the publication) • £1,000 – £5,000 (Subject to cost evidence for the publication of press notice, site notice and neighbour letters, and the consultancy's time spent on the publication) • £5,000 (Subject to cost evidence for the publication of press notice, site notice and neighbour letters, and the consultancy's time spent on the publication)

15 Pump-off

15.1 Introduction

The pump-off disposal method involves pumping the clear liquid portion of drilling wastes onto land (usually vegetated land) using irrigation equipment, such as a big gun, sprinkler, gated pipe, or perforated hose, or using water/vacuum trucks. Application rates must be calculated to ensure that the receiving soil meets the endpoints set out in section 3 directly after the drilling waste is applied and without incorporating it into the soil.

While pump-off is normally an off-site management option, this does not preclude pumping off small volumes on the well site that generated the drilling waste or on a remote sump site, provided the drilling waste was stored on the remote sump site. Small volumes of clear fluids may be pumped onto well site access roads provided these locations are leased or owned by the licensee and landowner/department/agency written consent has been obtained. Pump-off disposal on pipeline rights-of-way is limited to drilling waste resulting from directional drilling for construction of the associated pipeline. Water that has collected in cement return storage systems can be disposed of by the pump-off method provided that it meets the criteria listed below.

Refer to table 15.1 for a summary of the requirements for the pump-off disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

15.2 Pump-off Receiving Soil Requirements

1) Licensees must only select land for the pump-off disposal method that

   a) is free of unique features that would lead to pooling, erosion, or migration of the drilling waste;

   b) is not within 10 m of a road ditch or property line;

   c) is not within 100 m of a water body; and

   d) is not within 50 m of a water well.

   Note: Licensees may (notwithstanding requirement 1(c)) reduce the water body separation distance to 50 m if the water body is upgradient of the selected disposal area or if the landscape creates a physical barrier that would prevent the drilling waste from migrating towards the water body.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) Select one sampling site for each hectare of disposal area.

   b) Ensure each sampling site is a circular area with a 10 m radius and a centre precisely located and documented by GPS using the Universal Transverse Mercator (UTM) coordinate system, along with bearing and metres from a fixed point.

   c) At a minimum, collect one composite sample from the 0 to 10 cm soil depth increment and one from the 10 to 30 cm soil depth increment from each sampling site. Each composite sample must comprise five subsamples.

      Note: Licensees cannot take the result from the composite sample from the 0–10 cm soil depth and the result from the composite sample from the 10–30 cm soil depth and average them; each composite sample must be assessed separately.

3) Licensees must assess the receiving soil as set out in section 3 to confirm its suitability for the pump-off disposal method.

4) Licensees must (except when the disposal is occurring on a well site, remote storage site, or an area of a pipeline right-of-way that has a disturbed surface) obtain written consent from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to section 1.6) before beginning any landspray activities.

12.3 Pump-off Disposal Requirements

5) Licensees must only use the pump-off disposal method for the portions of water-based drilling wastes that qualify as clear liquids (i.e., do not contain any visible hydrocarbons and appear nonturbid when sampled from the discharge point; may be colourless or have natural colour or staining).

6) Licensees must sample and analyze the clear liquids for toxicity, pH, EC, SAR, Na, and N (if any of the additives/products added to the drilling mud system or drilling waste contain any amount of N [NH_4-N, NO_3-N, NO_2-N] or if the N content is unknown) to ensure that the liquids meet all of the following criteria:

   a) have a pH between 6 and 8.5; if the pH is adjusted, it must be reverified before pumping off; lab analysis is not required for a pH adjustment of less than 2 units;

   b) have an EC that does not exceed 10 dS/m;

c) pass a luminescent bacteria toxicity test before disposal (refer to section 4.3); if the initial toxicity assessment fails, but passes after being charcoal treated, the fluids must be analyzed for BTEX and F1 to F4 hydrocarbon fractions and the sum of the results must be less than 100 mg/L for pump-off to proceed; and

d) can be pumped off without exceeding a sodium loading rate of 250 kg Na/ha and a nitrogen loading rate of 25 kg N/ha.

7) Licensees must not exceed an "actual" application rate of 1000 m^3/ha.

8) If wishing to exceed the nitrogen application rate of 25 kg/ha, licensees must submit an application and obtain AER approval for an alternative management method as set out in section 19 of this directive; information based on section A2.3 of appendix 2 must be provided to support the application.

9) If the waste is treated, licensees must resample and reanalyze the waste to determine the applicability of this disposal method.

12.4 Pump-off Post-disposal Requirements

10) Licensees must conduct post-disposal sampling within 60 days of the disposal (but preferably directly after) and analyze the waste/soil mix to verify that the applicable soil endpoints set out in section 3 have not been exceeded if any of the following criteria are met:

a) If the EC of the clear liquid exceeds 5.0 dS/m, then analyze for EC and SAR.

b) If the sodium loading rate exceeds 150 kg/ha, then analyze for Na and SAR.

c) If the nitrogen loading rate exceeds 20 kg/ha, then analyze for N (NH_3-N, NO_3-N, NO_2-N).

Table 12.1 Summary of pump-off disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving soil • topsoil with EC <2 dS/m, SAR <4 Site • 50 m setback from a water well • 100 m setback from a water body • 10 m setback from a road ditch and property line • free of unique features that would lead to pooling, erosion, or migration of the drilling waste • landowner or Crown department/agency consent for disposal Waste • limited to clear liquid portion of water-based drilling waste • must pass a toxicity test	Clear liquids • pH between 6 and 8.5 • EC ≤10 dS/m • no visible hydrocarbons • if fails initial toxicity assessment, but passes after being charcoal treated, analyze for hydrocarbons; if total petroleum hydrocarbons >100 mg/L, do not proceed with pump-off • application rate to not exceed 1000 m^3/ha • pump-off must not result in pooling, runoff, or land erosion	Soil/waste mix limited to a maximum increase of one unit beyond background soil EC and SAR, but not to exceed an EC of 2 dS/m and an SAR of 4 Maximum Na loading rate: 250 kg/ha Maximum N loading rate: 25 kg/ha Soil/waste mix must not exceed soil hydrocarbon and trace element endpoints in tables 3.2 and 3.4	Receiving soil • EC and SAR Clear liquids • pH, EC, SAR, Na, and N (if any amount of N was added to the drilling mud or waste system or the N content is unknown) • toxicity assessment • hydrocarbons, if initial toxicity assessment fails, but passes after being charcoaled treated Waste/soil mix (post-disposal) • EC and SAR, if clear liquid exceeds an EC of 5 dS/m • Na and SAR, if the Na loading rate exceeds 150 kg/ha • N, if the N loading rate exceeds 20 kg/ha

[1] This table summarizes the pump-off requirements, but the details within the numbered requirements of section 12 will be used for assessing compliance with the pump-off disposal method.

13 Mix-Bury-Cover

13.1 Introduction

The mix-bury-cover (MBC) disposal method involves mixing nonhydrocarbon-based drilling waste solids or total waste with subsoils on the well site, pipeline right-of-way (provided the surface of the right-of-way is disturbed as identified in section 8 and the drilling waste is from the construction of the associated pipeline), or remote drilling waste storage site (provided the drilling waste was stored at the remote site), at a depth profile of 1 m to 1.5 m, or deeper than 1.5 m, to form a stabilized waste/soil mass that resides below the major rooting zone.

Typical MBC methods are

- to mix waste and subsoil in the sump and cover;
- to mix waste from the sump and subsoil on the surface, then put the mixture back in the sump and cover;
- to bail the waste from the sump onto the lease surface, mix with the subsoil, and bury when filling in a cut; or
- to spread the waste on the lease surface and allow it to dry; put the waste back into the sump, then mix and cover.

Licensees can use on-site management techniques (e.g., dewatering systems, shakers, solids control) to pretreat drilling waste before using this method. Refer to section 19 regarding AER approval for use of new technologies or treatment methods.

Refer to table 13.1 for a summary of the requirements for the MBC disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

13.2 Mix-Bury-Cover Receiving Soil Requirements

1) Licensees must conduct MBC disposals within deeper subsoils (i.e., at a depth profile between 1 m and 1.5 m or deeper than 1.5 m) on the well site, pipeline right-of-way, or remote drilling waste storage site.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

a) for disposal areas that are 3000 m^2 or less, collect a minimum of one composite sample comprising five subsamples;

b) for disposal areas that exceed 3000 m^2, divide the area into equal plots that are no larger than 3000 m^2 and collect one composite sample comprised of five subsamples for each plot;

c) collect each subsample at the soil profile depth for incorporation of the drilling waste (excluding clean fill/cap);

d) ensure the soil/waste mix sample is not diluted with soil from above or below the mix depth.

3) Licensees must assess the receiving soil as set out in section 3 to confirm its suitability for the MBC disposal method. If the drilling waste contains nitrogen or if the nitrogen content is unknown, licensees must also determine whether the receiving soil is coarse-grained (median grain size is greater than 75 microns) or fine-grained (median grain size is 75 microns or less).

13.3 Mix-Bury-Cover Disposal Requirements

4) Licensees must not manage drilling wastes resulting from hydrocarbon-based mud systems using the MBC method unless the waste has undergone biodegradation (refer to section 15).

5) Licensees must sample the drilling waste by taking either

a) a total waste (fluids and solids) sample, if both phases are being managed by MBC, or

b) a solids sample, if only the solid phase is being managed by MBC.

6) Licensees must have the sample analyzed for the following parameters and use the results to determine the soil/waste mix ratio that will prevent the receiving soil from exceeding the soil endpoints set out in section 3:

a) pH, EC, SAR, and Na;

b) nitrogen (N), if the additives/products used to formulate the drilling mud system or added to the drilling waste contain any amount of N (NH_3-N, NO_3-N, NO_2-N) or if the N content of any of the additives/products used to formulate the drilling mud system or added to the drilling waste is unknown;

c) metals, if the cumulative concentration of metals in mud additives/products added to the drilling mud system exceeds the values set out in table 3.4, or if metal content of the mud additives/product is unknown;

d) hydrocarbons (i.e., BTEX and F1 to F4 hydrocarbon fractions), if a hydrocarbon flag was encountered; and

e) toxicity, if mud additives/products were used in concentrations above the luminescent bacteria toxicity test pass threshold (EC50[15] ≥75 per cent), or if toxicity data are unknown. The sample must pass the toxicity test; for those drilling wastes that only pass the toxicity test after being charcoal treated, disposal may only proceed if hydrocarbons are the likely source of toxicity.

7) Licensees must mix the subsoil and drilling waste at a ratio of at least three parts subsoil to one part drilling waste. In addition,

a) licensees must use productive lab mixes to determine the soil/waste mix ratio for drilling wastes with an EC of 10 dS/m or more and an Na concentration of 3000 mg/L or greater (in saturated paste extract or filtrate from oversaturated sample).

(Refer to appendix 2, section A2.4, for the lab protocol for mixing drilling waste with receiving soil.)

b) licensees must not proceed with MBC operations when the productive lab or calculated mix ratios exceed seven parts soil to one part waste (alternative options include treating and retesting the waste to verify the suitability of the method, or using a different disposal method).

8) Licensees must not exceed a soil N endpoint (i.e., concentration of N [NH_4-N, NO_3-N, NO_2-N] in the soil/waste mix) of 10 mg/kg for coarse soils or 40 mg/kg for fine soils.

9) Licensees must cover the subsoil/waste mixture with a minimum of 1 m of clean fill. The EC and SAR of the clean fill must meet the Government of Alberta's *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2016) for the applicable soil rating category and depth.

Note: The use of naturally saline subsoils as the fill material may introduce unacceptable levels of salts to the rooting zone and may interfere with the final reclamation process and objective to restore the site to equivalent land capability.

10) Licensees must not conduct the MBC disposal within 10 m of an on-site rig water supply well. Should there be any concerns about protection of the wellhead during the MBC operation, the minimum 10 m distance must be appropriately increased. The soil/waste mix outer boundary must be at least 10 m from the rig water well.

11) If the waste is treated, licensees must resample and reanalyze the waste to determine the applicability of this disposal method.

12) If the site has previously been used for disposal, licensees must only proceed with the NSBC disposal if

a) the NSBC disposal occurs on an area of the site not previously used for drilling waste disposal, and all NSBC requirements are met; and

b) the use of the site for drilling waste management/multiple disposals has not exceeded a duration of five years, and any reuse of a sump or alternative storage system has followed the requirements set out in section 6.6.

13.4 Mix-Bury-Cover Post-disposal Requirements

13) Licensees must conduct post-disposal sampling of the waste/soil mix within 60 days of the disposal that predicably directly affects and compare the results to the applicable soil exposures set out in section 3 if any of the following criteria are met:

a) If the EC of the drilling waste exceeds 10 dS/m or the Na content of the drilling waste exceeds 3000 mg/L (in saturated paste extract or filtrate from oversaturated sample), then analyze for EC, SAR, and Na.

b) If the concentrations of metals in the drilling waste exceed the concentrations set out in table 3.3a or b, then analyze for metals.

c) If the concentration of hydrocarbons in the drilling waste exceeds the concentration for any of the parameters listed in table 3.3, then analyze for BTEX and F1 to F4 hydrocarbon fractions.

d) If the nitrogen concentration in the drilling waste (wet weight) is 6 mg/kg or more for disposals in coarse soils or 120 mg/kg or more for disposals in fine soils, then analyze for N (NH_4-N, NO_3-N, NO_2-N).

Table 10.1 Summary of risk-based cover-disposal method[1]

Pre-application conditions	Waste application specifics	Post-application conditions	Testing requirements
Receiving subsoil: • between 1 m and 1.5 m (or ≥ 0.5 above, GWR ≤ 0) • deeper than 1.5 m (or ≥ 0.5 or GWR limit) • first-grained soil Site: • 10 m setback distance between MBC operation and an on-site water well • unlimited to well-site, private survey site, or detached pipeline right-of-way Waste: • water-based drilling wastes or biodegradable hydrocarbon-based drilling wastes • solids or total (wet)% • must pass a toxicity assessment if a hydrocarbon Reg rate concentration, or if must satisfy/products solvs used to concentrations exceeding contaminant bacteria toxicity test threshold, or if toxicity data was unknown	Solids or total waste: • if solids/wet/amounts added to the incidentally applied, exhibit H_2S amount ≥ 0.5 m, if the % content was unknown, analyze the drilling waste for H and use the results to calculate spread rates • if hydrocarbon Reg concentrated, analyze one site (F1/2) and F1 to F4 hydrocarbon results to calculate spread rates in accord considerations of criteria in table 10.5 • must satisfy/products used to concentrations below this and, if applied must be 'non-exposure' bacteria toxicity test, or drilling waste passed toxicity test • if cumulative concentrations of metals in must satisfy/products exceed values in table 10.5 or you unknown, analyze drilling waste for metals, use results to calculate spread rates Subsurface moisture must be at least three cycle subsoil to one-pad drilling waste, not cannot exceed seven cycle subsoil to one-pad drilling waste. Lab shale must be used to determine subsoils into site shale drilling waste (≥ 1 m above or the ≤ GWR high, saturated pass) sample or Whole from consolidated waste.	Subsoils into limited to a maximum increase of: • top cycle for F2 and four cycle for F3/F4 beyond background soil conditions for MBC depths between 1 m and 1.5 m • three cycle for F2 and six cycle for F3/F4 for MBC depths at or below 1 m Subsoils into limited to a maximum % concentration of: • 2 mg/kg for mercury and • 25 mg/kg for Total soil Subsoils into must not exceed soil hydrocarbon and metals endpoints in tables 10.5 and 10.6 A minimum of 1 m of clean subsoil must cover applicable subsoil.	Receiving soil: • EC and SAR Waste and/or soil and waste: • pH, EC, SAR, Hg • for if solids/wet/amounts added to the drilling incidentally applied, exhibit H_2S amount ≥ 0.5 m, if the content was unknown • metals, if concentrations exceeding table 10.5 limits were added to the drilling mud system, or if the metals content of solids/wet/amounts is not known • hydrocarbons, if a hydrocarbon Reg rate concentrated • toxicity, if toxicity data was unknown for any of the must satisfy/products concentrations used in the drilling mud system, or if concentrations used exceeded table threshold for nonresearch bacteria toxicity test Restriction for cover-disposal: • EC, SAR, and Hg, if drilling waste EC > 4 dS/m or the SAR high saturated paste extract is Whole from consolidated waste • metals, if concentrations in the drilling waste exceed concentrations listed in table 10.5a or b • hydrocarbons, if concentrations in the drilling waste exceed concentrations listed in table 10.6 • if a Reg nitrogen concentration in the drilling waste was greater or at mg/kg for disposals in metals with a 4 000 mg/kg for disposals in first soil.

[1] See table summarizing the MBC requirements, and the details within the subsoil requirements in section 10.3.4.2, used in developing considerations with the MBC disposal method.

10 [illegible]

10.1 [illegible]

[illegible]

The landspreading method is not to be operating over injured drilling crew, to the landfarm, unless it is with the [illegible] of any open land fill, surface of the right of way is identified to receive it and the drilling crew is from the construction of the associated pipeline, or waste drilling muds storage, the open land fill, drilling muds can stored on the waste, but main landspreading is not the landfarm utilized.

Typical landspreading methods are:

a) [illegible] and ground [illegible] and incorporate the muds from the sump to soil, and

b) [illegible] the muds from the sump to the [illegible] incorporate it into the landfarm utilized.

Refer to table 10.1 for a summary of the requirements for the landspreading method, but not limited to the details within the specified requirements of ID2 and for operating conditions within the requirements.

10.2 [illegible]

1) [illegible] waste related landspreading of the landfarm utilized to [illegible] of the [illegible] of the soil, pipeline right of way, or waste drilling muds storage site.

2) [illegible] waste collect samples for assessing per [illegible] and additional [illegible] soil conditions as follows:

   a) for disposal area less [illegible] 1000 m³, collect a minimum of two composite sample comprising five subsamples;

   b) for disposal area from [illegible] 1000 m³, divide the area into equal grids that do not [illegible] 1000 m³, collect a composite sample comprising five subsamples for each grid;

   c) collect each subsample from the 0 - 15 cm soil [illegible] of the drilling muds depth [illegible] [illegible] cm from;

   d) ensure that the soil from the sample is not [illegible] with soil from [illegible] the [illegible].

3) [illegible] that [illegible] the [illegible] will be as near to section 7 to [illegible] to [illegible] the landspreading disposal method.

[illegible]

[illegible]

10.6 Landspreading: Post-disposal Requirements

(1) Licensees must conduct post-disposal sampling of the waste/soil mix within 60 days of the disposal (but preferably directly after) and compare the results to the applicable soil endpoints set out in section 7 if any of the following criteria are met:

(a) If the EC of the drilling waste exceeds 8 dS/m or the Na content of the drilling waste exceeds 1000 mg/L (in saturated paste extract or filtrate from oversaturated waste), then analyze for EC, SAR, and Na.

(b) If the concentrations of metals in the drilling waste exceed the concentrations set out in table 3 (a) or 4, then analyze for metals.

(c) If the concentration of hydrocarbons in the drilling waste exceeds the concentration for any of the parameters listed in table 3 (), then analyze for BTEX and F1 to F4 hydrocarbon fractions.

(d) If the nitrogen loading rate exceeds 300 kg/ha (prorated to the mass of N based on the actual area used for the landspread disposal), then analyze for N (NH_4-N, NO_3-N, NO_2-N).

Table 16.1 Summary of landspreading disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving subsoil • shallow subsoil to 1 m in depth: EC ≤3 dS/m, SAR ≤8 for soils in good category, EC of 3 to 5 dS/m, SAR of 4 to 8 for soils in fair category Site • 10 m setback distance between landspread operation and an on-site water well • restricted to well site, remote sump site, or disturbed pipeline right-of-way Waste • water-based drilling wastes or biodegraded hydrocarbon-based drilling wastes • solids or total waste • must pass a toxicity assessment if a hydrocarbon flag was encountered, or if mud additives/products were used in concentrations exceeding the luminescent bacteria toxicity test threshold, or if toxicity data are unknown	Solids or total waste • pH between 6 and 10.5 • N: <400 kg N/ha prorated to kg N/ha of actual disposal area • if hydrocarbon flag encountered, analyze drilling waste and use BTEX and F1 to F4 hydrocarbon results to calculate spread rates to prevent exceedances of criteria in table 3.2 • mud additives/products used in concentrations below the pass threshold level for luminescent bacteria toxicity test, or drilling waste passes toxicity test • if cumulative concentrations of metals in mud additives/products exceed values in table 3.4 or are unknown, analyze drilling waste for metals, use results to calculate spread rates Subsoil/waste mixture must be at least three parts subsoil to one part drilling waste, but cannot exceed seven parts subsoil to one part drilling waste Waste application rate must not exceed 1000 m³/ha or a thickness of 10 cm Lab mixes must be used to determine soil/waste mix ratio when drilling waste EC >8 dS/m or Na ≥2000 mg/L (saturated paste extract or filtrate from oversaturated waste), or if occurring on soils within the fair soil rating category	Soil/waste mix limited to a maximum increase of • two units for EC and three units for SAR beyond background soil conditions, but not to exceed EC of 3 dS/m or SAR of 6 when background soil EC < 3 dS/m and SAR < 4 • one unit for EC and two units for SAR beyond background soil conditions when background soil EC is 3 to 5 dS/m and SAR is 4 to 8 Maximum Na loading rate: 500 kg/ha when background soil EC <3 dS/m and SAR <4 Maximum N loading rate: 400 kg/ha Soil/waste mix must not exceed soil hydrocarbon and metals in tables 3.2 and 3.4	Receiving soil • EC and SAR Waste (solids or total waste) • pH, EC, SAR, Na • N, if an unknown amount or an amount ≥300 kg of N was added to the mud or waste system • metals, if concentrations exceeding table 3.4 limits were added to the drilling mud system or if the metal content of additives/products is not known • toxicity, if toxicity data are unknown for any of the mud additives/ products used in the drilling mud system or if concentrations used exceeded pass threshold for luminescent bacteria toxicity test • hydrocarbons, if a hydrocarbon flag was encountered Waste/soil mix (post-disposal) • EC, SAR, and Na, if drilling waste EC >8 dS/m or Na >2000 mg/L (saturated paste extract or filtrate from oversaturated waste) • metals, if concentrations in drilling waste exceed concentrations listed in table 3.5a or b • hydrocarbons, if concentrations in the drilling waste exceed concentrations listed in table 3.3 • N, if the nitrogen loading rate exceeds 300 kg/ha

[1] This table summarizes the landspreading requirements, but the details within the numbered requirements of section 16 will be used for assessing compliance with the landspreading disposal method.

15 Biodegradation

15.1 Introduction

The biodegradation disposal method involves the reduction of organic constituents in the drilling waste by a microbial process. Success involves optimizing conditions for microbial activity, such as temperature, pH, and moisture, nutrient, and oxygen content. The organic constituents must be biodegradable and not toxic to the micro-organisms.

Biodegradation is often used to manage drilling wastes contaminated with formation hydrocarbons or hydrocarbon-based drilling wastes. It can also be used to manage drilling wastes that contain other organics (e.g., starches, alcohols, and formates). The most common biodegradation techniques are land treatment and treatment within a contained system, such as in an impermeable cell structure or on an impermeable barrier (i.e., natural clay, compacted clay, or synthetic liner).

The following sections set out the requirements to biodegrade hydrocarbon-contaminated or hydrocarbon-based drilling wastes.

1) Licensees must apply to the AER and obtain AER written approval to either alter the requirements or biodegrade drilling wastes containing other organics. The application must contain scientific rationale that supports the changed requirements or that explains the biodegradation of the nonhydrocarbon organics (e.g., description of the mechanism for biodegradation, including any intermediate compounds and resulting breakdown compounds, as well as the fate and toxicity of the intermediate and resulting compounds in the environment). The application must also address the design and operation of the proposed biodegradation technique and site characterization (refer to section 19).

15.2 Drilling Waste and Site Characterization Requirements

Licensees must appropriately characterize drilling waste to determine whether the organic constituents are susceptible to biodegradation and whether there are recalcitrant constituents within the drilling waste (e.g., salts, metals) that must also be managed. The biodegradation of petroleum hydrocarbon is typically most successful when it consists of low molecular weight aromatics and aliphatics. Petroleum hydrocarbons containing a large fraction of asphaltenes or nitrogen- and sulphur-rich heterocyclic compounds may take a long time to degrade and may even produce toxic intermediates.

An assessment, such as a hydrocarbon fractionation characterization or treatability study, may be useful to predict biodegradation success in situations where an alternative organic-based drilling mud was used or where higher molecular weight hydrocarbons were added to the mud system or

infiltrated the drilling mud from the formation. An assessment may prevent future remedial actions, especially if land treatment was the chosen biodegradation method. Any biodegradation technique must not compromise future land capability and the ability to meet reclamation certification requirements.

When biodegrading drilling waste, licensees must ensure that the following requirements are met:

2) Irrespective of the biodegradation technique chosen, licensees must take a representative sample of the raw drilling waste and analyze it for the following:

   a) hydrocarbons (i.e., BTEX and F1 to F4 hydrocarbon fractions);

      Note: Refer to section A3.3 of appendix 3 for information about alternative methods of determining extractable hydrocarbons, which can be equated to the F2 to F4 hydrocarbon fractions in drilling wastes.

   b) salinity (EC, SAR) and total mineral nitrogen (NH_3^+, NO_2^-, and NO_3^-);

   c) pH;

   d) major ions (Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, NH_3^+, NO_2^-, NO_3^-, SO_4^{2-}, PO_4^{3-}); and

   e) metals, if the cumulative concentrations of metals in the mud additives/products added to the drilling mud exceed the values set out in table 3.4 or if the metal content of the mud additives/products is not known.

3) Before constructing the biodegradation area, licensees must prepare the site following typical well site and soil conservation practices. The biodegradation site must be located so that

   a) drainage ways and areas subject to seasonal flooding are avoided;

   b) it is at least 100 m away from a water body;

   c) it is at least 50 m away from a water well; and

   d) there is at least 10 m between an on-site rig water supply well and the area used for biodegradation.

4) If the biodegradation site is remote from the well site that generated the drilling waste, licensees must obtain a written agreement (e.g., surface lease or right-of-entry agreement or a disposition under the *Public Lands Act*) from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to section 1.5). In addition,

   a) licensees must have signage at the site entrance identifying the legal land location (LSD), the licensee, the well licence to which the site is linked (see [b] below), and a 24-hour

emergency phone number. The site must be secured so that it is not a public hazard (with measures to prevent the public or animals from accessing the drilling waste treatment area); and

b) the biodegradation site must be tied back (i.e., link) to the well licence of the well that generated the drilling waste. Where more than one well contributes to the waste being biodegraded, the biodegradation site must be tied back to the well licence that first contributed drilling waste.

5) Licensees must determine background soil conditions before beginning biodegradation operations. Sampling must, at a minimum, consist of the following:

a) Divide each hectare of land comprising a biodegradation area into four equal plots. For biodegradation sites that are less than 1 ha in size, divide the sites into equal plots that are no more than ¼ ha (2500 m^2) in size. Depending on the treatment method, take the following samples from each plot:

i) land treatment method

- combine a minimum of five soil samples from a 0–15 cm depth, or from the treatment zone (depth of incorporation), to form one composite sample; and
- combine a minimum of five soil samples from a 15–45 cm depth, or from the soil profile for 30 cm directly below the treatment or incorporation zone, to form one composite sample.

ii) biodegradation in a contained system

- combine a minimum of five soil samples from a 0–30 cm depth to form one composite sample; and
- combine a minimum of five soil samples from a 30–60 cm depth to form one composite sample.

b) Analyze each sample for

i) pH,

ii) salinity (EC, SAR) and total mineral nitrogen,

iii) major ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, NH_3^{+}, NO_2^{-}, NO_3^{-}, SO_4^{2-}, PO_4^{3-}),

iv) median grain size, per cent clay, per cent sand, per cent fines, plasticity index (PI), and liquid limit (LL), and

v) metals as listed in table 3.4.

c) Analyze a discrete soil sample for each depth profile set out in 5(a)(i) or (ii) above for BTEX and hydrocarbon fractions F1 through F4, unless there is sufficient site information to substantiate the absence of hydrocarbons in the soil (e.g., the area was previously undisturbed and is unlikely to be subject to contaminant migration from other areas of the site or from off-site sources).

6) Upon closure, licensees must re-evaluate soil conditions of the biodegradation site as follows:

a) Sample and analyze each plot as set out in requirements 5(a), (b), and (c) above, and depending on treatment method, also do the following sampling and analysis for each plot:

i) land treatment method

- take a minimum of one soil sample (not composited) for each depth (0 to 15 cm or treatment zone, and 15 to 45 cm or soil profile for 30 cm below the treatment zone), and analyze for BTEX and hydrocarbon fractions F1 to F4.

ii) biodegradation in a contained system

- take a minimum of one sample (not composited) for each depth (0 to 30 cm and 30 to 60 cm), and analyze for BTEX and hydrocarbon fractions F1 to F4.

b) If there is evidence of contamination in the deeper soil sample (15 to 45 cm for land treatment and 30 to 60 cm for biodegradation in a contained system), sample at 30 cm intervals, and analyze the samples following the protocol set out in requirements 5(a), 5(b), and 6(a) above, until the extent of contamination has been delineated. The contaminants must be remediated; then the site must be resampled.

The above are minimum requirements to establish background and closure soil conditions. It may be prudent to determine background conditions for the 45 to 75 cm depth for land treatment and the 60 to 90 cm depth for biodegradation in a contained system to prevent the use of sites that have existing contamination concerns.

7) Licensees must close sites used to biodegrade drilling waste within five years of the date that the biodegradation commenced. Upon completion of the biodegradation activity, the site must not exceed the soil quality endpoints set out in section 3 (for salinity endpoints, refer to the criteria applicable to land treatment in table 3.1).

8) In addition to meeting the soil quality endpoints, licensees must ensure that the closure of a remote biodegradation site (i.e., not on the well site) includes site reclamation. Licensees must obtain documentation from the appropriate department/agency indicating that the biodegradation site has been reclaimed and meets equivalent land capability as identified in section 1.6 (i.e., reclamation certificates from the appropriate agency for sites defined as specified lands), and make it available to the AER upon request.

9) Licensees must electronically submit a notification to the AER at least 30 days before the beginning of the biodegradation activity. The notification must include:

   a) the licensee name and business associate (BA) code;

   b) the well licence number and UWI of the well that generated the drilling waste, or the legal land location of the remote sump/storage system that contains the drilling waste to be biodegraded; the well licences of all of the wells that contributed to the drilling waste; and the well licence and UWI to which the remote sump/storage system and biodegradation site will be linked (i.e., the first well that contributed drilling waste);

   c) the legal land location of the biodegradation site; and confirmation, if required, that written landowner/department/agency consent has been obtained for the activity;

   d) the volume and type of drilling waste to be biodegraded;

   e) the type of biodegradation method (e.g., land treatment, biodegradation in a contained system);

   f) the commencement date for the biodegradation activity; and

   g) licensee commitment that all applicable requirements in section 15 will be adhered to.

10) Licensees must electronically submit the notification to the AER in PDF as an e-mail attachment as follows:

   a) E-mail the notification to Directive050@aer.ca.

   b) Ensure that the attachment file name identifies it as a drilling waste biodegradation notification, contains the applicable well licence number and the UWI, and is formatted as DW_Licence#_UWI (e.g., BiodegradationDW_0123456_00~12-14-025-12W4~0).

   c) Ensure that the subject field of the e-mail contains the file name.

   Note: The AER will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliance.

11) Licensees must file a second notification following the directions in requirement 10 above if the biodegradation site cannot be closed within five years. The notification must describe the biodegradation process used and the circumstances that impeded it, the amount of biodegradation that has occurred, the expected additional time needed to achieve closure endpoints, and the rationale supporting how extending the biodegradation duration would result in meeting applicable endpoints, taking into consideration the circumstances that impeded the process.

Where the biodegradation operation is on a site remote from the well site, the AER will assess the information submitted in the notification to determine if the licensee must undergo the approval process for an oilfield waste management facility.

15.3 Biodegradation of Drilling Waste by Land Treatment

15.3.1 Method Description

Land treatment involves applying the drilling waste from one well or one waste set (i.e., contents of a remote sump that only received drilling waste from one licensee's drilling program over one drilling season) to a dedicated parcel of land and cultivating it into the receiving subsoil, where the inherent soil processes biodegrade, transform, and assimilate the waste constituents.

Land treatment may be conducted from the well site or on a site remote from the well site. Drilling waste managed by land treatment becomes assimilated within the soil in which it was mixed. To maximize the success of land treatment and to minimize soil and environmental damage, the application rate and incorporation depth of the drilling waste is limited.

This method requires tillage and application of nutrients to break down the petroleum hydrocarbon in the drilling waste. Small amounts of amendments (e.g., nutrient, organic) may be added to enhance the biodegradation process.

Aeration materials (e.g., wood chips, sawdust, straw) may be used in limited quantities (less than 10 per cent of the drilling waste volume), but excessive volumes of these materials could lead to site reclamation challenges. Sampling and analysis are necessary to monitor the progress of biodegradation.

15.3.2 Design and Operation

12) Licensees must select a land treatment site that is relatively level and does not have a slope that exceeds 3 per cent.

(15) Licensees must limit the receiving soil, which is often referred to as the treatment zone, to shallow subsoils (to a maximum depth profile of 1 m) that are in the good or fair soil rating category, as set out in table 3.1.

(16) Licensees must ensure that the receiving soil or treatment zone (which is typically 15 cm in depth) has:

(a) clay content greater than 15 per cent, a sand content less than 70 per cent, and a texture that will allow contaminants within the drilling waste to be effectively mixed with the soil, yet retained within the treatment zone, and

(b) pH within the range of 6 to 8.5.

(17) Licensees must ensure that the maximum depth of the treatment zone is at least 1 m above the saturated zone.

(18) For groundwater protection, licensees must ensure that the soil for 10 cm below the treatment zone is of limited permeability and has a clay content (i.e., particle size of 0.002 mm or smaller as determined by hydrometer methods) of at least 20 per cent, a fines content (defined as dry weight percentage passing a no. 200 sieve) of at least 30 per cent, a PI equal to or greater than 10, and an LL equal to or greater than 30.

(19) Licensees must ensure that the depth of waste incorporation into the receiving soil does not exceed that of normal cultivation equipment, typically 15 cm.

(20) Licensees must mix the drilling waste into the receiving soil at a mix ratio of one part drilling waste to a minimum of three parts soil by volume. Mix ratios and amendments must be managed to ensure that the treatment area can be restored to equivalent land capability.

(21) Licensees must ensure that the receiving soil is not saturated with water, covered with ice or snow, or frozen when the drilling waste is being applied.

(22) After mixing the drilling waste with the receiving soil, licensees must ensure that the treatment zone meets the following criteria:

(a) metal concentrations must not exceed the limits listed in table 3.4 or the background concentrations for the receiving soil if any background soil metal concentrations exceed the limits in table 3.4;

(b) EC and SAR values must not exceed the maximum allowable increase from background values or the maximum EC and SAR values for the applicable soil horizon, depth, and rating category, as set out in table 3.1; and

(d) the total petroleum hydrocarbon content [illegible] and (if it is) the hydrocarbon fractions must not exceed [illegible] mass.

(3) A licensee must ensure that the prohibited limit is below the petroleum hydrocarbon content in the treatment zone in land closure criteria [illegible] the judgement set out in table 1 is then not exceed five years.

(3) A licensee must form the land treatment area [illegible] and to allow any generated leachate to collect and to prevent [illegible] any source of surface runoff. A licensed facilities not be

(a) irrigated over the land treatment area [illegible] in does not hinder the biodegradation process or create a soil quality problem; or

(b) managed following the pump-off disposal [illegible] set out in section 13; or

(c) injected down an approved disposal well; or

(3) A licensee may remove the leachate after use in [illegible] but any of the requirements before must be met

(a) A 1 1 consent of treatment zone material by soil water (gases) a homogenous factors in every test

(b) The leachate collected from the land treat [illegible] water (or greater) water collected within the formed used the three consecutive list in [illegible] more than (gas 2 months has an acceptable hydrocarbon (EC or 010 [illegible] level that does not exceed 3 mg/l, and that passes a luminescent bacteria toxicity test. If more [illegible] mass be collected for each event.

The need for leaves must be re-circulated [illegible] or other materials are added to the treatment site.

(3) A licensee must work the land treatment area [illegible] and to ensure during the active biodegradation period, active allow [illegible] the 4/08.

13.4 Biodegradation of Drilling Wastes in a Contained System

13.4.1 Method Description

Biodegradation of drilling waste in a contained [illegible] the process where drilling waste is biodegraded in a contained and controlled environment, such as in an impermeable cell or in an impermeable barrier. This technique may be of [illegible] interest when

[illegible]

[illegible]

[illegible]

[illegible]

10.8 Information Requirements for Biodegradation Operations

[10] Licensees must document information to verify that the drilling waste and site characterization requirements set out in section 10.2 were met.

[11] Licensees must also document the type of biodegradation operation (i.e., land treatment or biodegradation in a contained system) and the following information:

a) if biodegradation is being conducted on a site remote from the well site, a copy of the written agreement with the landowner or department/agency managing the land on behalf of the provincial or federal government and the well licence to which the remote site is tied back or linked (refer to section 10.2[10][b]);

b) the type of drilling mud system and fluid additives/mud products used;

c) the volume of drilling waste being managed, and the location, name, and licence number of the wells that generated the drilling waste;

d) the number, location, and depth of samples taken to characterize the biodegradation site, and the analytical results from the samples (i.e., background soil conditions);

e) if a contained system operation, containment system design and construction details supporting that

i) migration of contaminants beyond the containment system was prevented,

ii) any generated leachate was collected, and

iii) the entrance of surface waters into the containment system was prevented;

f) if a land treatment operation,

i) the information to support that the treatment zone and underlying soil were appropriate for the technique (i.e., per cent sand, loam, and clay; median grain size, LL, PI); and

ii) the dimensions of the area used for land treatment, and the drilling waste application method, rate, and depth of incorporation (i.e., the treatment zone);

g) a sketch of the site, including the biodegradation containment system or land treatment area and other key features, such as slope, topography, drainage features, surface water run-on control/leachate collection system, bodies of water, and water wells; and,

i) if on the well site, the location of the sump and well relative to the biodegradation area must also be identified on the sketch; or

c) if off the well site, the biodegradation area must be mapped as a rectangle with the coordinates for the northeast and southwest corners being referenced from the northeast corner of the applicable section;

h) the commencement date of the biodegradation process and a photo of the area;

i) a description of the work done to manage, enhance, and monitor the biodegradation process, such as aerating the drilling waste mass or treatment zone, applying amendments, and sampling and analyzing the drilling waste mass or treatment zone, and

i) the description must include the date the work was done, the method used to conduct the work, types and rates of amendments that were added, and the manner in which the waste mass or treatment zone was sampled and the results of the analysis;

j) the volume of any leachate collected, its characteristics, and how it was managed;

k) AER approvals if the biodegraded drilling waste removed from the containment system was used as a by-product; and

l) confirmation that the biodegradation site has been closed (i.e., soil conditions have been evaluated, the soil endpoints in section 3 have been met, and the site has been reclaimed and restored to equivalent land capability) and the date closure was achieved.

3.3) Licensees must retain the documented information to make available to the AER upon request.

3.4) In addition to the notification requirements in section 15.2 (requirements 9–11), licensees must also fulfill the pre- and post-disposal notification requirements set out in sections 21.2 and 21.3.

16 Subsurface Disposal of Drilling Waste While Drilling

16.1 Introduction

Under appropriate conditions, subsurface disposal of drilling waste can be carried out without jeopardizing groundwater or impacting hydrocarbon-bearing zones. This method is a planned process that involves disposing drilling waste down the wellbore of a well that is in the process of being drilled and has had surface casing set and cemented to a depth that will cover the known base of groundwater protection. The zone being used for disposal of the drilling waste must be isolated from any hydrocarbon-bearing zones and groundwater.

16.2 Requirements

1) Licensees wishing to use this method must submit an application to the AER and obtain written approval before beginning disposal.

2) Licensees must provide the following information in the application:

   a) the type of drilling waste (e.g., freshwater gel chemical, salt water gel chemical, invert based) and volume to be managed by this method; confirmation that the drilling waste has a flash point that exceeds 60.5°C; the well licence number; and the surface hole and bottomhole location of the well that generated the drilling waste;

   b) the depth and geological formation to which the drilling waste will be disposed and the wellbore that will be used, including the well licence number, UWI, and surface location of the well;

   c) confirmation that there is a minimum of 150 m between the base of groundwater protection and the zone being used for disposal and that there is an impermeable formation separating the two zones;

   d) verification that the zone being used for disposal does *not* contain hydrocarbons within 1.6 linear kilometres (km) of the intended well being used for disposal;

   e) a plan that outlines the circumstances of the disposal, including a discussion as to whether the disposal is to occur in an open hole, behind cemented casing, or any other scenario;

   f) the estimated pressure needed to pump the drilling waste into the formation; and

   g) any other information as requested by the AER.

3) Licensees must submit the application through the Electronic Application Submission (EAS) process accessed through the Digital Data Submission (DDS) screen on the AER website at www.aer.ca.

Authorized AER customers require a login ID and password to access the DDS system. For help getting a login ID, please contact your company's AER DDS administrator. If you are unable to contact your company's AER DDS administrator, contact DDSAdministrator@aer.ca.

The AER will return applications that do contain all of the required information to the licensee and will consider commencement of any activity associated with the application as a noncompliance.

17 Sending Drilling Waste to Approved Waste Management Facilities

17.1 Introduction

This section summarizes the requirements for the use of approved waste management facilities for drilling waste management. Waste management facilities include landfills, waste processing facilities, biodegradation facilities, thermal treatment facilities, and surface facilities associated with waste caverns and Class I disposal wells. Note that mobile thermal treatment units are not considered waste management facilities; refer to section 18 for requirements regarding the use of mobile technology to thermally treat drilling waste.

Drilling waste generated in Alberta is a specific type of oilfield waste. When sending drilling waste to an approved waste management facility for treatment, processing, or disposal, licensees must adhere to all AER requirements pertaining to the management of oilfield wastes. This includes appropriate waste classification, characterization, and tracking.

In Alberta, waste management facilities are regulated by either the AER or EP. EP regulates most landfills in the province. Licensees must ensure that AER requirements are not contravened when using EP-regulated waste management facilities.

As part of its compliance assurance process, the AER will conduct drilling waste audits to check for compliance with AER requirements. In the event of an audit, a licensee must submit relevant information to support that the use of a waste management facility for the drilling waste in question complied with AER requirements.

17.2 Requirements

This section summarizes oilfield waste management requirements applicable to drilling waste being sent to approved waste management facilities. The AER regulatory documents that set out the requirements are listed below, and any updates or changes to the requirements in these documents will supersede direction provided in this section:

- *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*
- *Interim Directive (ID) 2000-3: Harmonization of Waste Management*
- *ID 2000-4: An Update to the Requirements for the Appropriate Management of Oilfield Wastes*
- *ID 99-4: Deposition of Oilfield Wastes into Landfills*

1) Licensees must ensure the waste management facility is approved, and the facility approval must authorize the receipt of wastes exhibiting the properties of the drilling waste in question and the type of activity that will be used to manage the drilling waste. In addition, licensees must ensure use of the waste management facility does not contravene any of the restrictions or prohibitions listed in the following requirements.

   Note: Waste management facilities reducing the hydrocarbon content of oilfield wastes and drilling wastes by volatilization (passive or active) must be approved for the activity.

2) Licensees must

   a) retain information pertaining to the use of an approved waste management facility in the well file of the well that generated the waste;

   b) make the information available to the AER upon request; and

   c) use the information to support an application for reclamation certification of the well site or associated remote site, if applicable.

3) Licensees must ensure that drilling waste being sent to an approved waste management facility in Alberta is classified as either a dangerous oilfield waste (DOW) or a non-dangerous oilfield waste (non-DOW) as specified in Part B of *Directive 058*.

   Note: The properties that typically cause drilling waste to be classified as DOW are flammability (flash point less than 60.5°C; note that the *Transportation of Dangerous Goods Regulations* specifies a flash point of ≤60°C), leachate toxicity (leachable BTEX values exceed criteria in the *Alberta User Guide for Waste Managers*, published by Alberta Environmental Protection), and corrosivity (pH value less than 2 or greater than 12.5).

   The properties and criteria defining DOWs and hazardous wastes will be the same in AER and EP requirements. Guidance documents developed by each agency and recommendations given to industry on the characterization and classification of specific wastes, the properties to be measured, the analytical methods to be used, and the chemical parameters to be tested will be consistent with the *Alberta User Guide for Waste Managers*.

4) For drilling waste that is classified as DOW, licensees must only send the waste to facilities approved to receive DOWs, hazardous wastes, or hazardous recyclables (drilling waste must be recycled if it is being sent to a recycling facility) as set out in *Directive 058*, *ID 2000-3*, and *ID 2000-4*.

5) If transporting drilling waste classified as DOW to a waste management facility in Alberta, licensees must ensure the waste is accompanied by a properly filled out Alberta Oilfield Waste Form as set out in Part C of *Directive 058* and *ID 2000-3*.

Note: Shipments of wastes classified as DOW are subject to the *Transportation of Dangerous Goods Regulations*.

Note: Drilling wastes being exported out of Alberta are subject to the waste classification and manifest requirements under *EPEA* as identified in *ID 2000-3*.

6) For all drilling wastes sent to AER- or EP-regulated waste management facilities, as well as those exported for treatment or disposal, licensees must ensure the wastes are tracked as reportable oilfield wastes as set out in Part C of *Directive 058* and *ID 2000-4*.

Note: The waste codes for drilling waste (DRWSHC – hydrocarbon, DRWSGC – gel chemical, DRWSAC – advanced gel chemical) listed in appendix 3 in *Directive 047: Waste Reporting Requirements for Oilfield Waste Management Facilities*, the Waste Management Table in appendix 7 of *Directive 058* and any other subsequent updates, must be used to track the drilling wastes.

7) Licensees must ensure drilling waste is not mixed with any solids or liquids for the primary purpose of diluting it to avoid any Alberta regulatory requirement as set out in section 5.5 of *Directive 058*.

8) Licensees sending drilling waste to landfills must comply with the following requirements:

a) It is prohibited to deposit drilling waste into any registered landfill or any landfill currently operating under an Alberta Public Health permit that will qualify for registration under the *Code of Practice for Landfills*, pursuant to *EPEA* as set out in *ID 2000-4*.

b) Drilling waste sent to a landfill must pass the paint filter test (i.e., it must be a solid) and must be characterized and classified prior to the addition of adsorbents or bulking materials (e.g., sawdust, woodchips) as set out in *Directive 058* and *ID 99-4*.

Provided that the drilling waste qualifies for acceptance into a landfill (passes paint filter test, does not exceed any waste acceptance criteria for the landfill, and waste classification is appropriate for the class of landfill), the subsequent addition of sorbent material required to facilitate its handling and to manage any interstitial liquids that could shake out during transportation to the landfill is acceptable.

c) Drilling waste sent to an approved Class II landfill must be classified as a solid, non-DOW as set out in *Directive 058* and *ID 99-4*. If the landfill has design features alternative to a

leachate collection and removal system and an engineered clay liner or synthetic liner, the concentrations of chloride (Cl) and total petroleum hydrocarbon (TPH) in the drilling waste must be correlated to the design of the landfill as set out in *ID 99-4* as summarized below.

Class II landfill design feature[2]	Oilfield waste quality
Leachate collection/removal	TPH no limit
Engineered clay[3] or synthetic liner	Cl no limit
No leachate collection/removal	TPH <30 000 mg/kg
Engineered clay or synthetic liner	Cl <5000 mg/kg
No leachate collection	TPH <20 000 mg/kg
Natural clay liner[4]	Cl <3000 mg/kg

[2] All Class II landfills require surface water run-on/run-off control systems, suitable hydrogeology, and groundwater monitoring.

[3] Engineered clay liner: a liner constructed of appropriate clayey material where the material is laid down in 150 to 250 mm lifts, and each lift is compacted at 2 to 3 per cent wet of optimum moisture using a sheep's foot roller such that a thickness of 0.5 m or more and a hydraulic conductivity of 10^{-9} metres/second (m/s) or less is achieved.

[4] Natural clay liner: a liner constructed by scarifying and recompacting the native material (soil) in which the cell is built.

d) Drilling waste sent to approved Class III landfills must be classified as a solid, non-DOW and must be inert[1] as set out in *Directive 058* and *ID 99-4*.

e) Drilling waste classified as DOW destined for landfill disposal must only be sent to a Class I landfill provided the drilling waste passes the paint filter test and does not exceed acceptance criteria for the landfill as set out in *Directive 058* and *ID 2000-4*.

9) Licensees must not send drilling waste to compost facilities or compost components at waste management facilities, including EP-regulated landfills as set out in *ID 2000-4*.

10) Licensees must not send drilling waste to dedicated land treatment facilities (i.e., facilities approved by, or registered with, EP for the treatment of soils contaminated with refined hydrocarbons) as set out in *ID 2000-4*.

[1] Inert waste is any solid waste that upon disposal in a landfill is not reasonably expected to undergo physical, chemical, or biological changes to such an extent as to produce substances that may cause an adverse effect. Examples include demolition debris, concrete, asphalt, glass, scrap metal, and dry timber or wood that has not been chemically treated. Drilling wastes and cement returns will generally require extensive treatment before being rendered inert.

18 Use of Mobile Thermal Treatment Units to Manage Drilling Waste

18.1 Introduction

Mobile thermal treatment units, which are regulated by EP, may be used to thermally treat drilling waste provided that the units have received approval from or have been registered with EP. Although thermal treatment can effectively reduce hydrocarbons and other organic compounds, it can also concentrate recalcitrant constituents, such as salts and metals. Upfront characterization of drilling waste is necessary to assess the options available for the final disposition of the thermally treated drilling waste (e.g., land application options or disposal at an approved waste management facility). The requirements in this section are based on those set out in section 17.5 of *Directive 058*, and any updates to section 17.5 will supersede the requirements of this section.

18.2 Thermally Treating Drilling Waste Requirements

1) Licensees must only conduct thermal treatment operations on a licensed well site or on a remote drilling waste storage or biodegradation site. Only drilling waste from the well where the unit is located can be treated. If the unit is on a remote drilling waste storage or biodegradation site, only the drilling waste generated by the well program being managed on the remote site can be treated.

2) Licensees must ensure the mobile treatment unit has an approval or registration from EP, and all operations of the thermal treatment unit are in accordance with the approval or registration conditions. Drilling waste that exhibits properties that would classify it as a dangerous oilfield waste must only be treated by thermal treatment units approved by EP to treat hazardous waste.

3) In alignment with section 5.5 of *Directive 058*, licensees must ensure drilling waste is not mixed with any solids or liquids for the primary purpose of diluting it to avoid any Alberta regulatory requirement (i.e., reduce constituent levels to change the drilling waste classification from a DOW to a non-DOW or to make it meet requirements specified for operation of the thermal unit).

4) Licensees must meet AER storage requirements (refer to *Directive 055: Storage Requirements for the Upstream Petroleum Industry*) while conducting thermal treatment operations, and the operation of the thermal treatment unit must not result in a contravention of any license or approval condition for the well site or remote site.

7) Thirty days prior to beginning thermal treatment operations, licensees must electronically submit a notification to the AER containing the following:

   a) the location of the well site (surface) or remote drilling waste storage or biodegradation site on which the mobile thermal treatment unit will be located;

   b) the well licence number and UWI, if the mobile thermal treatment unit is located on the well site, or if located on a remote drilling waste storage or biodegradation site, the well licence and UWI to which the remote site is linked (see sections 4.4(10) and 11.2(4));

   c) the company operator of the mobile unit and the EP approval or registration number;

   d) the volume and type of drilling waste (e.g., invert or hydrocarbon based, or previously treated waste) to be treated by the mobile unit;

   e) the final disposition planned for the treated drilling waste (e.g., landspread or WSE following the requirements in Directive 058, or disposal at an approved waste management facility); and

   f) the duration of the thermal treatment activity.

8) Licensees must electronically submit the notification to the AER in PDF as an e-mail attachment in accordance with the following requirements:

   a) E-mail the notification to [illegible].

   b) Ensure that the attachment file name identifies it as a drilling waste thermal treatment notification, contains the applicable well licence number and the UWI of the well that generated the drilling waste, and is formatted as DW_Licence#_UWI (e.g., ThermalTreatDW_0123456_00-12-34-05-12W4.pdf).

   c) Ensure that the subject field of the e-mail contains the file name.

The AER will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliance.

9) Thirty days before beginning thermal treatment operations, licensees must notify all landowners and residents within a 1.5 km radius of the site of the details of the intended activity. If the EP approval or registration for the thermal treatment unit identifies conditions for public notification, then the most stringent public notification requirements must be met.

10) Licensees must notify the local AER field centre of the details of the intended activity at least 48 hours before beginning thermal treatment operations.

(b) Licensees must track the volume and type of drilling waste that results, received, or is left at the final disposition of the treated drilling waste, and include this information in the post-disposal notification as required by section (1) d.

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

1) [redacted]

2) [redacted]

[redacted]

[redacted]

1) [redacted]

   a) [redacted]

   b) [redacted]

[illegible]

[redacted]

20 Removing a Former Drilling Waste Disposal

20.1 Introduction

Prior to 1995, drilling waste management direction was limited, and common practices included backfilling sumps and burying drilling waste. *Guide 50*, now *Directive 050*, was first issued in 1995 and then was updated in 1996. Remediation and reclamation guidelines have advanced significantly since 1996, which can present challenges when trying to obtain regulatory closure (i.e., reclamation certification) for well sites and associated sites used to manage drilling wastes. In some cases, licensees have conducted phase 2 environmental site assessments and determined that exhuming the drilling waste disposal area and removing it with subsoil would resolve the remediation and reclamation challenges.

While removing has advantages over excavating and hauling the drilling waste to a waste management facility (often referred to as dig and dump, which also requires the excavation to be filled with suitable subsoils), it can significantly disturb the site. This option is limited to drilling waste disposals where current landspread or MMC soil endpoints (refer to tables 3.1, 3.2, and 3.4) can be met using a mix ratio of no more than three parts subsoil to one part drilling waste. The size of the disturbance caused by the remove activity must also be evaluated when considering this option.

This section sets out the requirements to remove an old drilling waste disposal, as well as a notification process for the activity.

20.2 Requirements to Remove a Former Drilling Waste Disposal

1) Licensees must meet the following requirements when removing old drilling waste disposals:

   a) The remove must only be conducted on a licensed well site or associated remote drilling waste storage site on which an original drilling waste disposal occurred.

   b) The old drilling waste disposal area must be vertically and horizontally delineated.

   c) Representative samples must be been taken and lab analyzed to determine background soil conditions and the quality of the drilling waste disposal area. samples must be analyzed for hydrocarbons (BTEX components and F1–F4 hydrocarbon fractions), metals, major ions, EC, and SAR.

   d) Predictive lab mixes must be done to determine the soil/waste mix ratio that will meet the soil endpoints for salts, hydrocarbons, and metals for landspread or MMC as set out in tables 3.1, 3.2 and 3.4 (refer to section 8.2.4 of appendix 2 for information about lab predictive mixes).

e) The mix ratio for the remix must not exceed 3 parts subsoil to 1 part drilling waste.

f) The remix must be done at the soil horizon depth that correlates to the salinities set out in table 3.1 for the landspread or MHC option being used.

g) The volume of the drilling waste and soil to be removed must be determined and used to gauge the size of disturbance needed for a successful remix.

h) The pros and cons of the site disturbance required for the remix option must be compared with those of the dig and dump option.

i) If the site is on public lands, the AER must agree with the remix option.

20.3 Notification Requirements

2) Licensees must electronically submit a notification to the AER at least 30 days before beginning remix activity. The notification must, at a minimum, contain the following information:

a) date of notification;

b) name, address, and phone number of the licensee;

c) legal land location (surface) of the site on which the remix is to take place and the licence number and UWI of the well that generated the drilling waste or of the well to which the site is linked (refer to section 6.4[19]);

d) a description of the proposed remix with supporting documentation to substantiate the appropriateness and applicability of the remix, which must include

i) the history of the site, including the year of the original drilling waste disposal;

ii) a plot plan identifying the area of the original drilling waste disposal, the area encompassing the proposed remix, the location and depths of the boreholes/samples taken to delineate and assess the conditions of the original drilling waste disposal and background soils, and the topographical features of the site and any existing infrastructure;

iii) soil borehole logs from the site assessment, summary of the analytical results and lab productive mixes to substantiate that the remix will achieve the endpoints set out in tables 3.1, 3.3, and 3.4;

iv) the soil horizon depth at which the remix is to occur, the soil-to-waste mix ratio used for the remix, and the remix disposal method (i.e., landspread with good category

subsoils, landspread with fair category subsoils, MBC between 1 and 1.5 m deep with good or fair category subsoils, or MBC at 1.5 m or deeper with no subsoil category restriction); and

v) if the site is on public lands, correspondence to confirm that the AER is in agreement with the remix.

3) Licensees must electronically submit the notification to the AER in PDF as an e-mail attachment as follows:

a) E-mail the notification to Directive050@aer.ca.

b) Ensure that the attachment file name identifies it as a drilling waste remix notification, contains the applicable well licence number and the UWI of the well that generated the drilling waste or to which it is linked, and is formatted as DW_Licence#_UWI (e.g., RemixDW_0123456_00-12-14-025-12W4-0).

c) Ensure that the subject field of the e-mail contains the file name.

The AER will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliance.

4) Licensees must notify the local AER field centre and give them the details of the intended remix at least 48 hours before beginning.

21 Record Keeping and Notification

21.1 Introduction

The record keeping and notification requirements in this section pertain to drilling wastes from wells. Record keeping and notification requirements for drilling wastes from pipelines are set out in section 8 of this directive.

21.2 Record Keeping Requirements

The AER requires licensees to maintain records to demonstrate compliance.

1) Licensees must document the following information and retain it in the well file of the well that generated the drilling waste and make the information available to the AER upon request:

   a) The surface land location, UWI, and well licence number of the well that generated the drilling waste.

   b) The type of drilling mud system used, including

      i) a list of all fluid additives and mud products used;

      ii) the volume of each fluid additive and mud product added;

      iii) luminescent bacteria toxicity documentation, if available, for all fluid additives and mud products used; and

      iv) metal content documentation, if available, for all of all of the fluid additives and mud products used and the cumulative metal content of the mud system.

   If different mud systems were used for different sections of the hole and were segregated and managed separately, the above information must be documented for each system.

   c) The method used to store the drilling waste, including information to demonstrate compliance with section 6 of *Directive 050* and a plot plan identifying the location of the storage system, and the following, as applicable:

      i) If a remote site was used to store drilling waste, in addition to the above, the legal land location of the remote site and a copy of the written agreement for use of the site from the landowner or Crown department/agency managing the land (refer to section 1.5).

      ii) If more than one well contributed drilling waste to the storage system, the well licence of the well that first contributed drilling waste (i.e., well licence to which the remote site is linked as set out in section 6.4[19]).

d) The volume of drilling waste generated and the management method used, including

i) drilling waste assessment information, including analytical and field testing results, as well as a sketch of the sump or drilling waste storage system showing the locations and depths of the subsamples taken to obtain the representative composite drilling waste sample;

ii) the name, location, and approval number of any waste management facility to which drilling waste was sent;

iii) the following information for any land application/disposal method used (sections 9 to 14):

- receiving soil assessment information,
- if applicable, post-disposal sampling information,
- a detailed map of the disposal area,
- proof of landowner/department/agency consent, and
- the drilling waste disposal rates and supporting calculations.

e) If different drilling waste types (as a result of different mud systems being used) or phases (e.g., clear liquids, fluids, solids, cuttings, total waste, cement returns, drillstem test fluids) were segregated, the information in (b), (c), and (d) above must be documented for the management of each segregated type or phase.

f) If biodegradation was used to manage the drilling waste, the information requirements in section 15.5 must also be documented.

2) Licensees must retain the information from requirement 1 above in the well file until the well site and any associated remote drilling waste storage or biodegradation site have successfully been reclaimed (this involves getting, for specified lands, a reclamation certificate from the AER; for nonspecified lands, documentation from the department/agency managing the land on behalf of the Crown identifying that reclamation requirements have been met).

21.3 Pre-disposal Notification Requirements

3) Licensees must electronically submit drilling waste disposal notification information in conjunction with the drilling activity notification through the AER Digital Data Submission (DDS) system, Field Surveillance Inspection System (FIS) Drilling Activity Notification Form.

4) Licensees must enter the following information about the proposed drilling waste disposal activities on the Drilling Activity Notification Form:

   a) drilling fluid/mud type(s);

   b) proposed drilling waste disposal method(s) and location(s);

   c) location of remote sump or biodegradation site, if one is to be used; and

   d) environmental contractor information.

Changes to the drilling activity notification record are allowed on the DDS system up to 48 hours from the drilling activity start date. Licensees should consider the drilling waste disposal before this time passes and update the drilling activity notification with appropriate information. Any changes to the disposal plan after 48 hours from the drilling activity start date must be clearly documented and retained in the well file. Changes to the drilling activity start date can also be made provided the new date is within 48 hours of the original date. For a change that exceeds 48 hours, licensees are to contact the appropriate AER field centre and provide the new date and any corresponding changes to the drilling waste disposal plan, if required.

Authorized AER customers require a login ID and password to access the DDS system. For help getting a login ID, please contact your company's AER DDS administrator. If you are unable to contact your company's AER DDS administrator, contact DDSAdministrator@aer.ca.

Detailed instructions for submitting information about drilling activities (including drilling waste information) is in the FIS website user guide. Inquiries may also be directed to the FIS administrator by telephone at 403-297-4845 or by e-mail at FIS.administrator@aer.ca.

21.4 Post-disposal Notification Requirements

5) Licensees must also electronically submit post-disposal information identifying the drilling waste volumes actually generated, the management or disposal options used, and the disposal locations. A Directive 050: Drilling Waste Management Disposal Form must be filled out for each well licence and submitted within 24 months of rig release.

6) Licensees must submit the disposal information through the DDS system on the AER website at www.aer.ca. The disposal form is located in the DDS system under AER > Submissions > DrillingWasteData > SubmitWasteData; select Well Disposal as the Submission Type. Licensees must also retain a copy of the completed form in the well file.

Authorized AER customers require a login ID and password to access the DDS system. For help getting a login ID please contact your company's AER DDS administrator. If you are unable to contact your company's AER DDS administrator, contact DDSAdministrator@aer.ca.

Appendix 1 *Directive 050* Background

The AER[1] first provided direction on drilling waste management in 1975 with the publication of *Interim Directive OG 75-2: Sump Fluid Disposal Requirements*. Changes in drilling mud technology and an increased awareness of the need to protect the environment resulted in a review of drilling waste characteristics and the development of the 1993 edition of *Guide 50: Drilling Waste Management* (now known as *Directive 050*).

A review of data from about 4200 wells resulted in the 1995 publication of the *Interim Working Document for Drilling Waste Management*, which was introduced with *General Bulletin 95-04: Drilling Waste Management*. The interim working document provided updates on sampling and analytical requirements, data requirements, and criteria for drilling waste disposals.

Additional review of the interim working document resulted in the publication of the 1996 edition of *Directive 050*. The disposal methods set out in the 1996 edition specified maximum loading rate (in kilograms per hectare) or total load (in kilograms) of a parameter in the drilling waste that could be applied to land. It also required that a notification of drilling waste disposal be submitted to the appropriate regulatory agency at certain stages of the disposal and that a copy of the notification be submitted to the drilling waste database, which was maintained by CGI Information Systems and Management Consultants Inc. for the Canadian Association of Petroleum Producers (CAPP). CAPP stopped funding this database in 2004.

In 2006, the AER issued *Directive 045: Digital Data Submission of Drilling Waste Disposal Notification*, which changed the notification requirements and clarified that the AER is the regulatory agency responsible for drilling waste management in Alberta.

The early 1990s saw the publication of numerical criteria for soils, which served as benchmarks against which to assess the degree of contamination at a site, the need for remediation, and the acceptable concentration of soil contaminants. Examples include the Canadian Council of Ministers of the Environment *Interim Canadian Quality Criteria for Contaminated Sites* (1991) and Alberta Environment[2] *Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation* (1994).

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[1] On June 17, 2013, the *Responsible Energy Development Act* was proclaimed, and the AER was created. Although activities may have taken place under its predecessors, for simplicity "the AER" will be used in this appendix.

[2] On May 24, 2015, Alberta Environment and Sustainable Resource Development became Alberta Environment and Parks (EP). Although activities may have taken place under EP's predecessors, for simplicity "EP" will be used in this appendix.

Through the late 1990s, national environmental quality assessment and management guidelines were developed using a conservative, generic form of risk assessment designed to preserve a range of developments, activities, and conditions with distinct land use categories or sensitivities (CCME 1996a, b, 1997, and 1999). EP also applied the concept of risk assessment for the derivation of soil and remediation objects set out in

- *Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Petroleum Oil and Gas Sites* (2001);
- *Soil Remediation Guidelines for Barite: Environmental Health and Human Health* (2004 and updated 2009); and
- *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2007 and updated 2008, 2009, 2010, 2012, 2014, and 2016).

Also through the late 1990s and early 2000s, the AER worked with EP to ensure that there was a harmonized approach to waste management and to clarify regulatory roles and responsibilities in this area. The need to harmonize drilling waste management requirements with other waste management requirements, combined with the advancement of environmental quality guidelines and the development of the 2003 Upstream Oil and Gas Reclamation and Remediation Program, resulted in a government/industry multistakeholder review of the 1996 edition of *Directive 050*. The AER chaired the review. The information generated through the review and in current regulatory documents was used to develop a draft revision to *Directive 050*, which was released for public review on September 10, 2007.

The comments received were assessed against current soil, environmental, and analytical sciences, as well as against regulatory requirements and procedures. To assist with this assessment, the AER held meetings and corresponded with representatives of industry and environmental associations and of federal and provincial government agencies. The 2007 draft edition of *Directive 050* was revised and released for a second round of public review on April 18, 2011.

The AER considered the comments received through the public review, in consultation with EP, in finalizing the 2012 edition of *Directive 050*.

The AER recommends that further investigation be done to determine the feasibility of using terrestrial toxicity tests to set toxicity threshold levels for drilling fluid additives and mud products and to identify environmentally toxic drilling wastes.

Appendix 2 Salinity and Nitrogen

A2.1 Introduction

To preserve good-quality soils, drilling wastes must be managed to comply with the following in the soil-waste mix:

- a maximum allowable increase in electrical conductivity (EC) and sodium adsorption ratio (SAR), and
- an upper limit on post-disposal EC and SAR.

The allowable increases and upper limits are set out in table 3.1 and depend on the receiving soil rating category and depth, as well as the drilling waste disposal method.

Waste application limits based on calculations involving EC, SAR, and sodium concentration are the most comprehensive analytical parameters to use to establish a waste's salinity. From these values, calculated spread rates or productive mixes can be carried out to determine safe addition levels. The purpose of this appendix is to provide salinity calculations for each drilling waste disposal method. A recommended lab mixing protocol is also provided at the end of this appendix.

It must be emphasized that site-specific conditions, such as particular environments and climatic conditions, may result in the specified EC and SAR limits being too high for environmental protection.

A2.2 Salinity Calculations

A2.2.1 Mix-Bury-Cover

The following simplified calculations may be used for wastes with an EC less than 10 dS/m as an alternative to productive lab mixes.

Electrical Conductivity

The following calculations should be used to determine mix ratio as a function of waste EC.

Equation (1) for oversaturated wastes:

$$\text{Mix ratio} = \frac{\text{Waste EC} - \Phi}{\text{EC target increase}} - 1 \qquad (1)$$

Mix ratio = Ratio of soil to waste

Waste EC = Electrical conductivity (dS/m) of saturated paste extract

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - SG_{dw}}{1.65}$$

SG_{dw} = Specific gravity of the solid waste, measured using an American Petroleum Institute (API) recommended procedure

EC target increase = Maximum EC increase from table 1.1 (dS/m)

Equation (3) for water saturated wastes

$$\text{Mix ratio} = \frac{\text{Waste EC} \times S_L S}{\text{EC target increase} \times (1 - \Phi_s)} - 1 \qquad (3)$$

Mix ratio = Ratio of soil to waste

Waste EC = Electrical conductivity (dS/m) of saturated paste extract

EC target increase = Maximum EC increase from table 1.1 (dS/m)

$S_L S$ = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(SG_{sp} \times 1)}{(2.65 - SG_{sp})}$$

SG_{sp} = Specific gravity of a saturated paste made from the waste, measured using an API recommended procedure

Φ = Volume fraction of water in waste $= \frac{2.65 - SG_{dw}}{1.65}$

A2.2.2 Landspreading and Land Treatment

Electrical Conductivity

Mix ratios must first be calculated using equation (1) or (3). The waste application rate is then calculated using equation (5):

$$\text{Application rate} = \frac{\text{Tillage depth} \times 100}{\text{Mix ratio} + 1} \qquad (5)$$

Application rate = Waste application rate (m³/ha)

Tillage depth = Depth (cm) of tillage from top of waste layer

Mix ratio = Ratio of soil to waste (v:v)

Soil Conversion Factor for Electrical Conductivity

Equations 1.5 and 1.6 assign a gross increase in soil EC regardless of background soil EC. When backgrounding or load to remove excess above the 1 m depth, the post-dogleg soil EC could not exceed the maximum EC in table 1.1. In order to ensure that the maximum EC is not exceeded, a conversion factor must be applied for soils with a background EC greater than 1 dS/m. The waste application rate must be multiplied by the soil conversion factor for all soils with a background EC greater than 1.

The soil conversion factor for subsoil is calculated using equation 1.8, and the conversion factor for topsoil is calculated using equation 1.9.

$$\text{Soil EC conversion Factor (subsoil)} = \frac{5 - \text{Background soil EC}}{5} \quad (1.8)$$

$$\text{Soil EC conversion Factor (topsoil)} = 1 - \text{Background soil EC} \quad (1.9)$$

Background soil EC = Electrical conductivity of soil before waste application (dS/m)

Equations 1.8 and 1.9 must not be used when background soil EC is less than 1 dS/m.

Sodium

The sodium application rate must not exceed 500 kg/ha. The sodium-based loading rate should be calculated using the following equations:

Equation 1.10 for recommended waste

$$\text{Waste application rate} = \frac{\text{SAR} \times \text{RR}}{\text{Waste Na concentration} \times \Phi} \quad (1.10)$$

Waste application rate = Waste application rate (m/ha)

Waste Na concentration = Sodium concentration in waste (mmol$_c$/L)

Φ = Volume fraction of water in waste = $\frac{1 \times \text{SG}_{\text{water}} - \text{SG}_{\text{dry}}}{1 \times \text{SG}_{\text{water}}}$

SG_{dry} = Specific gravity of the field-moist waste, measured using an OPC and balance

Equation (7-5) for ammoniacal nitrogen

$$\text{Application rate} = \frac{\text{N AR} - \text{N Crd Crdt}}{\text{Ammo N in concentration} \times \text{AE}} \quad (7\text{-}5)$$

Application rate = Ammo application rate per Year

N AR = Mass of nitrate or ligand in ammoniacal gram content of crops

$$\frac{\text{Wt kg} \times \%}{1{,}000} = \text{Wt kg}$$

Wt kg = Specific gravity of a ammoniacal gram water from the crops, measured using an AR Land Database

Ammo N in concentration = Nutrient concentration in crops Wastes (kg/t)

AE = N Matter Applied of Crops to crops = $\frac{\text{U.F.} \times \text{Wt kg}}{\text{U.F.}}$

4.E.2.2 Laboratory

The application rate for fertility crops should be based on AR and soil test fertility tests. Specific requirements after apply to nitrogen crops to

Soil Conversion Factor for Ammoniacal Fertilizers

The NAGroup operations allow a 1 Wet manure to soil AE. To ensure that the AE form of 1 Wet is not exceeded, a conversion factor must be applied for each crop's Background AE greater than 1 Wet. The soil conversion factor is calculated using equation (7-6). The crops application rate must be multiplied by the soil conversion factor for all soils in the Background AE greater than 1 Wet.

$$\text{Soil conversion factor} = \frac{1}{\text{Background soil AE}} \quad (7\text{-}6)$$

Background soil AE = Ammoniacal nutrient no. of soil before crops application Wet

Equation (7-6) need not be used when Background soil AE is less than 1 Wet.

Installations with Solid Incompressibles – Maximum Fill Rate Method

The following rate of application should be used to determine application rate of a Watering of a unit of Soil for each soil's Underground Fill (1.1 Litres or more).

Equation (6-1A) is a metric unit system:

$$\text{Application rate} = \frac{\text{Fillage Depth} \times \text{Fc}}{\text{Wetted Fill} \times \text{Ap}} \quad \text{(6)}$$

Application rate = Water application rate (cc/ Day)

Fillage Depth = Depth of Fillage (cm) (decimal) (1 cc)

Wetted Fill = Wetted soil volume by Litres of soil (cm)

Fc = Fc factor (fraction of water to water) = $\frac{\text{Fill} - \text{Fill Rate}}{\text{Fill}}$

Ap (Ap) = Specific gravity of the water (measured using an Ap Fill Fluid Balance)

Equation (6-1A) is a conventional system:

$$\text{Application rate} = \frac{\text{Fillage Depth} \times \text{Fc} \times \text{Ap}}{\text{Wetted Fill} \times 2.2 \times \text{Ap}_w} \quad \text{(6)}$$

Application rate = Water application rate (oz/ Day)

Fillage Depth = Depth of Fillage (inch) (decimal) (2.2 oz)

Fc = Ratio of Fill Fluid to the total of water (mass of water)

$$\text{Ap} = \frac{\text{Fillage}}{\text{Fill} - \text{Fillage}}$$

Ap (Ap) = Specific gravity of the saturated water (mass of water) (measured using an Ap Fill Fluid Balance)

Wetted Fill = Fill (inch) (decimal) by Litres of saturated water (mass)

Ap = Volume Fraction of water to water = $\frac{\text{Fill} - \text{Fillage}}{\text{Fill}}$

The maximum rate rate should be used to maximize fill rate of the Fillage depth (1.1 oz) between 2 oz and 3 oz maximum Fillage depth of Incompressibles. Water application rate should be determined by the Fillage depth before the soil is saturated.

[illegible]

[illegible]

[illegible]

$$[illegible] = \frac{[illegible]}{[illegible]} \quad (xx)$$

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

$$[illegible] = \frac{[illegible]}{[illegible]} \quad (xx)$$

[illegible]

[illegible]

[illegible]

$$[illegible]$$

[illegible]

[illegible]

$$[illegible]$$

Landspray with No Soil Incorporation – Electrical Conductivity

The following calculations should be used to determine application rate as a function of waste EC.

Equation (12) for oversaturated wastes:

$$\text{Application rate} = \frac{1000}{\text{Waste EC} \times \Theta} \qquad (12)$$

Application rate = Waste application rate (m^3/ha)

Waste EC = Electrical conductivity (dS/m) of waste slurry

Θ = Volume fraction of water in waste = $\frac{2.65 - SG_{fm}}{1.65}$

SG_{fm} = Specific gravity of the field-moist waste, measured using an API mud balance

Equation (13) for undersaturated wastes:

$$\text{Application rate} = \frac{SL/S \times 1000}{\text{Waste EC} \times (1 - \Theta_S)} \qquad (13)$$

Application rate = Waste application rate (m^3/ha)

SL/S = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(SG_{sp} \times 1)}{(2.65 - SG_{sp})}$$

SG_{sp} = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Waste EC = Electrical conductivity (dS/m) of saturated paste extract

Θ = Volume fraction of water in waste = $\frac{2.65 - SG_{fm}}{1.65}$

A minimum application rate of 10 m^3/ha is recommended for calculating salinity loading rates.

Landspray with No Soil Incorporation – Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using either equation (10) or (11).

Equation (10) for oversaturated wastes:

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration} \times \Phi} \qquad (10)$$

Waste application rate = Waste application rate (m^3/ha)

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

Φ = Volume fraction of water in waste $= \frac{2.65 - SGfm}{1.65}$

SGfm = Specific gravity of the field-moist waste measured using an API mud balance

Equation (11) for undersaturated wastes:

$$\text{Application rate} = \frac{SLR \times 250\,000}{\text{Waste Na concentration} \times (1 - \Phi)} \qquad (11)$$

Application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(SGsp - 1)}{(2.65 - SGsp)}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Φ = Volume fraction of water in waste $= \frac{2.65 - SGfm}{1.65}$

Additional Restrictions

Waste application rates based on salinity or sodium should not override the solids loading limit of 6 t/ha if the waste is not being incorporated into the soil.

The pH of waste applied to vegetated land must not be less than 6.0 or more than 10.5.

Caution should be exercised when applying saline wastes to hay and pasture land where salt-sensitive species are growing. Salt-sensitive species include red clover, alsike clover, alfalfa, and

timothy. The potential for damage to vegetation is especially high when the soil is dry. Extreme caution should be used when conducting landspray disposals on no-till fields in the spring before seeding.

A2.2.4 Landspray While Drilling

A maximum EC of 16 dS/m is recommended for all landspray-while-drilling (LWD) operations, except nitrogen systems (refer to section A2.3). Although disposal with soil incorporation is at the discretion of the landowner, the LWD method is designed to ensure that the drilling waste/soil mix meets all applicable endpoints without incorporation.

Soil Correction Factor for Electrical Conductivity

The following equations allow a 1 dS/m increase in soil EC. To ensure that the EC limit of 2 dS/m is not exceeded, a correction factor must be applied for soils with a background EC greater than 1 dS/m. The soil correction factor is calculated using equation (5). The waste application rate must be multiplied by the soil correction factor for all soils with a background EC greater than 1.

$$\text{Soil correction factor} = 2 - \text{Background soil EC} \qquad (5)$$

Background Soil EC = Electrical conductivity of soil before waste application (dS/m)

Equation (5) must not be used when background soil EC is less than 1 dS/m.

Electrical Conductivity

Equation (12) should be used to determine application rate as a function of waste EC.

$$\text{Application rate} = \frac{160}{\text{Waste EC} \times \Phi} \qquad (12)$$

Application rate = Waste application rate in m^3/ha

Waste EC = Electrical conductivity of waste slurry in dS/m

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{1.65}$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

A minimum application rate of 10 m^3/ha is recommended for the purposes of calculating salinities load rates.

Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using equation (10).

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration} \times \Phi} \qquad (10)$$

Waste application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{1.65}$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

Other Restrictions

Waste application rates based on salinity or sodium must not exceed the solids loading limit of 6 t/ha.

The pH of waste applied to vegetated land should not be less than 6.0 or more than 10.5.

Caution should be exercised when applying saline wastes to hay and pasture land where salt-sensitive species are growing. Salt-sensitive species include, but are not limited to, red clover, alsike clover, alfalfa, and timothy. The potential for damage to vegetation is especially high when the soil is dry. Extreme caution should be used when conducting LWD disposals on no-till fields in the spring prior to seeding.

A2.2.5 Landspraying on Forested Public Lands

Electrical Conductivity

Waste EC should not exceed 10 dS/m. The waste application rate must not exceed 80 m^3/ha.

Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using either equation (10) or (11).

Equation (10) for oversaturated wastes:

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration} \times \Phi} \qquad (10)$$

Waste application rate = Waste application rate (m^3/ha)

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

Φ = Volume fraction of water in waste = $\frac{2.65 - \text{Waste specific gravity}}{1.65}$

SGfm = Specific gravity of the field-moist waste measured using an API mud balance

Equation (11) for undersaturated wastes:

$$\text{Application rate} = \frac{\text{SLR} \times 250\,000}{\text{Waste Na concentration} \times (1 - \Phi)} \qquad (11)$$

Application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(\text{SGsp} - 1)}{(2.65 - \text{SGsp})}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Φ =Volume fraction of water in waste = $\frac{2.65 - \text{SGfm}}{1.65}$

A2.2.6 Pump-off

Soil Correction Factor

The following equation allows a 1 dS/m increase in soil EC. In order to ensure that the EC limit of 2 dS/m is not exceeded, a correction factor must be applied for soils with a background EC greater than 1 dS/m. The soil correction factor is calculated using equation (5). The waste application rate must be multiplied by the soil correction factor for all soils with a background EC greater than 1.

$$\text{Soil correction factor} = 2 - \text{Background soil EC} \qquad (5)$$

Background soil EC = Electrical conductivity of soil before waste application (dS/m)

Equation (5) must not be used when background soil EC is less than 1 dS/m.

Electrical Conductivity

Waste EC should not exceed 10 dS/m.

The application rate for waste that does not contain nitrogen should be based on EC and sodium loading rate. The following calculation should be used to determine application rate as a function of waste EC:

$$\text{Application rate} = \frac{1600}{\text{Waste EC}} \qquad (14)$$

Application rate = Waste application rate in m^3/ha

Waste EC = Electrical conductivity of waste slurry (dS/m), maximum 10 dS/m

Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using equation (10).

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration}} \qquad (10)$$

Waste application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

Other Restrictions

The pH of waste applied to vegetated land should not be less than 6.0 or more than 8.5.

Caution should be exercised when applying saline wastes where salt-sensitive species are growing. Salt-sensitive species include red clover, alsike clover, alfalfa, timothy, and many forest species. The potential for damage to vegetation is especially high when the soil is dry. Caution must be exercised under dry conditions, and it may be necessary to use other disposal options.

A2.3 Recommended Nitrogen Loading Rate Objectives

In some cases, landowners may wish to apply nitrogen-containing drilling wastes to land to increase the amount of nitrogen in the soil. Depending on the composition of the drilling wastes, either salinity or nitrogen may be the limiting parameter when wastes are surface applied. The importance of EC and SAR in determining salinity must be balanced against nitrogen loading criteria. Calculations for determining whether the waste application rate must be based on salinity or nitrogen are provided under each surface disposal option. **Licensees wishing to apply drilling wastes to land using nitrogen loading rates must apply to the AER for approval before**

beginning the disposal. The application must contain sufficient information to support the nitrogen loading rates.

A2.3.1 Determining When Nitrogen Application Rates May be Used for Landspray, Landspray While Drilling, Pump-off, and Disposal onto Forested Public Lands

Application rates based on product addition that result in <25 kg N/ha do not require specific nitrogen analysis and should be disposed of according to EC and SAR requirements. The nitrogen application rate may be estimated as follows:

$$\text{N application rate} = \frac{\text{Units of product used} \times \text{mass/product unit} \times \text{N in product}}{\text{Disposal area} \times 100} \qquad (15)$$

N application rate = Amount of N applied in waste (kg/ha)

Units of product = Number of product containers used (sack/pail/drum)

Mass/product unit = Mass of product in container (kg/container)

N in product = Concentration of N in product (%)

Disposal area = Area to which waste is applied (ha)

All sources of nitrogen must be considered, and recycled wastes must include all product additions (e.g., all mud addition on previous and current wells).

Assessing Salinity in Nitrogen-based Wastes

If the nitrogen application rate, according to equation (15), is equal to or greater than 25 kg/ha, the nitrogen loading limits in table A2.2 or site-specific application rates must be used. Because nitrogen and non-nitrogen salts both contribute to salinity, the following equation must be used to determine whether non-nitrogen salinity constraints override nitrogen-based application rates. If the EC to nitrogen ratio measured in the waste is greater than the critical ratio calculated by equation (16), waste application rates must be based on EC (or sodium, whichever is lower) loading limits, as specified above.

$$\text{Critical EC: N Ratio} = \frac{\text{Mixing depth} \times 0.027}{\text{N application rate}} + \text{Conductivity factor} \qquad (16)$$

Critical EC:N ratio = Ratio of waste EC (dS/m) to waste N concentration (mg/L)

Mixing depth = Depth (cm) of tillage or infiltration

If wastes are incorporated into the soil, use the tillage depth to a maximum of 10 cm.

If wastes are not incorporated into the soil, use 30 cm for pump-off and 3 cm for LWD, disposal onto forested public lands, and landspray.

Waste N concentration = Sum of all mineral N species (NH_4-N, NO_3-N, NO_2-N) (mg/L)

N application rate = Amount of N applied in waste (kg/ha) from table A2.2

Conductivity factor = Electrical conductivity (dS/m per mg N) due to nitrogen salts (from table A2.1)

Table A2.1 Conductivity factors for equation 16

Conductivity factor	
$Ca(NO_3)_2*4(H_2O)$	0.012
KNO_3	0.010
NH_4NO_3	0.0041
$(NH_4)_2SO_4$	0.0076
$NaNO_3$	0.0087

Nitrogen Application Rates

The guidelines in table A2.2 should be used when nitrogen application rates will be equal to or greater than 25 kg/ha. Site-specific nitrogen application rates may also be used, based on a soil fertilizer recommendation determined by a qualified agrologist from soil test data. The land manager should be fully informed of the nitrogen rate applied.

Nitrogen-based waste application rates should be calculated using the following equations.

Equation (17) for oversaturated wastes:

$$\text{Waste application rate} = \frac{\text{N application rate} \times 1000}{\text{Waste N concentration} \times \Phi} \qquad (17)$$

Waste application rate = Waste application rate (m^3/ha)

N application rate = Amount of N applied in waste (kg N/ha) from table A2.2

Waste N concentration = Sum of all mineral N species (NH_4-N, NO_3-N, NO_2-N) (mg/L)

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{1.65}$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

Equation (18) for undersaturated wastes

$$\text{Application rate} = \frac{\text{N application rate} \times \text{SLR} \times 1000}{\text{Waste N concentration} \times (1 - \Phi)} \qquad (18)$$

Application rate = Waste application rate (m^3/ha)

N application rate = Amount of N applied in waste (kg/ha) from table A2.2

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(SGsp - 1)}{(2.65 - SGsp)}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Waste N concentration = Sum of all mineral N species (NH_4-N, NO_3-N, NO_2-N) (mg/L)

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{2.65}$

SGfm = Specific gravity of the fluid-moist waste, measured using an API mud balance

Table A2.3. Recommended nitrogen loading limits (kg N/ha)[1] for landspray, landspray while drilling, dispersal onto forested public lands, and pump-off[2]

	Cropped, dryland	Cropped, irrigated	Tame forage (including pasture)	Native prairie	Forest
No farmer applied nitrogen	70	140	50	50	200
Farmer applied moderate rate of nitrogen but no soil test	35	70	25	25	n/a
Farmer applied nitrogen to meet soil test recommendation	0	0	0	0	0

[1] Nitrogen loading limits are expressed as the mass (kg) of N per hectare, measured as mineral nitrogen (nitrate-nitrite-ammonium).

[2] Nitrogen loading limits may be adjusted using guidance from tables 2 and 3 in the *Alberta Fertilizer Guide* (2004 or an updated by Alberta Agriculture, Food, and Rural Development) and in consultation with the landowner.

A2.6 Lab Protocol for Mixing Drilling Waste with Receiving Soil

Analytical data for lab-made mixtures can be used to estimate mix characteristics after disposal, as well as the minimum soil-to-waste mix ratio needed in the field in order to meet post-disposal criteria. Good field sampling and submission to the lab of homogeneous, representative material will reduce discrepancies due to sample variability. An obstacle in the lab in obtaining an accurate estimate of the required mix ratio is the difficulty of reproducing field conditions. Samples of receiving soil are generally disturbed and thus low-dense than in the field. Clay samples in particular may be lumpy and have large voids. For this reason, weighing a sample of the receiving soil and assuming a soil bulk density appropriate for the type of soil involved is considered the best way to estimate a desired field condition volume.

A2.6.1 Suggested Protocol

1) Homogenize the moist soil, if necessary, by screening up to 1 kg through 1 mm.

   a) If the waste is undemonstrated but moist, screen up to 500 g (1 mm) and dry @ 103°C.

   b) If the waste is already completely dry, break it up in a mortar and pestle to pass 1 mm.

   c) Agitate unconsolidated wastes that have a separate liquid phase (e.g., shake the container well).

In all cases, after having homogenized the soil and waste, take the following steps, which are designed to minimize interlab discrepancies, to allow for changes in bulk density during collection and shipping of soil samples and to mirror on-site bulk volume mixing methods.

2) Determine per cent moisture (% mois.) of the soil by drying a subsample at 103°C.

3) Fill a small, 1 L plastic pail with enough moist soil to make a nominal saturated paste.

4) Weigh the pail and contents to determine the moist weight of the soil in it.

5) Calculate dry weight of the soil as follows:

   Dry weight (g) = moist soil weight (g) ÷ (100 + % mois. [as received]) ÷ 100

   or

   Dry weight (g) = moist soil weight (g) ÷ 100 ÷ (% mois. [dry basis] + 100)

6) Determine the required waste volume to add using the following formula:

   Waste volume (mL) = dry weight of soil (g) ÷ factor

In the above formula for the required water volume, the "factor" is not dependent on the standard fluid and no-waste rem ratio, as listed below:

Factor*	Dry volume ratio
0.8	0.1
2.3	0.1
10.9	0.1

*Factor = rem ratio + (bulking liquid at rem rem density - bulking liquid at required water volume) / (bulking liquid at rem density - bulking liquid at 100% compartment fluid) The bulking liquid density is using to 100% compartment fluid. The bulking liquid density is using the same rem fluid density.

7) Measure out the required water volume, and add it to the soil in the 1 L pail. For undisturbed matter, use a weight of homogenized dry waste from step four or the corresponding to the required water volume from step 5. by means of the following equation:

Dry waste weight (g) = Water volume (mL) × (Mg/m³ value)

Where (Mg/m³) = dry bulk density of the waste (in Kg/m³). Obtained as described in section 64.4 (4b).

8) Add water and blend on as to bring the mixture to a saturated paste condition. Allow beige to soak before blending, use an electric blender if desired.

9) Cover the pail loosely and leave the blended mixture at bays bus hours or preferably overnight (16 hours) to allow volatile salts to approach equilibrium.

10) Blend in more water, if necessary, to re-establish saturating.

11) Measure weight loss cup (WPC) on a silhouette of paste to obtain per cent saturation.

12) Record pH of the paste. Wipe and test Obtain the salinity assessment.

References: Ashworth and Mcintyre. 2004. Proceedings of the xxx Effective Soil Science Workshop, p. xx–xx.

[1] Suggestion: Using water density = 1.00 g/mL) a typical of waste, weigh into will when required volume is a disposable cup marking the outside of the cup at the water level. Record the water and subsequent marks in the note-taking or by placing the cup base on the bench top, then remove the water into the pail of soil, making the cup with the correct amount of distilled water.

Appendix G [illegible]

G1.1 Introduction

[illegible] a system to set out [illegible] a consolidated guidelines require that the methods of applying water to land for [illegible] ensure that the resulting soil water mix does not exceed the applied guidelines values. From a hydrocarbon perspective, the 1999 edition of Victoria EPA has not [illegible] ensure that disposal operations meet the 'Waters Environmental Objectives (Groundwaters) Guidelines (2018)'. Bunbury wishes adjacent the soils receiving drilling waste have been established based on these guidelines and we can see a table 1.1.1 of the relevant [illegible]

By hydrocarbon flags consist of which indicates of full provisions of hydrocarbons in drilling wastes. The [illegible] of Victoria EPA requires that drilling wastes be treated for hydrocarbons (Hydrocarbon flags) have been considered and that the waste be used to make decisions about disposal methods and also and about the need to sample the resulting material and other disposal.

G1.2 Hydrocarbon Flags

Historic scientific data of hydrocarbon contamination in drilling waste is not collected as part of an available [illegible] in the 1999 Drilling Waste Victoria Report, which took place during an earlier version of Victoria EPA. This information is not considered to be of a [illegible] if [illegible]

By 1999 information identified that drilling wastes that contained significant hydrocarbons in its ones from treatment where hydrocarbon flag was indicated. Wastes generated from a drilling operation are hydrocarbon flagged if:

- the soil is [illegible]
- a diesel spill was added
- any other hydrocarbons were added through drilling practices such as underbalanced drilling or drilling muds, or
- there are any visible hydrocarbons in the drilling waste.

By Victoria Environment document are set hydrocarbon guidelines for benzene, toluene, ethyl benzene, and xylenes (BTEX) and hydrocarbon fractions C6 - C9 (TPH C_6 - C_9), C10 - C14 (TPH C_{10} - C_{14}), and C15 - C28 (TPH C_{15} - C_{28}). In some of the 1999 information could not provide an indication as to whether volatile hydrocarbons (BTEX) and C6 were a concern. In the guidelines values for volatile hydrocarbons are quite low. Concern can understand that a visible indicator (e.g. [illegible]) against BTEX and C6 concentrations.

(6.1) Hydrocarbon Analysis

Section 4 contains all 24 hydrocarbon concentrations collected, and Section 5 uses only the calculated hazard or aerosol data and the total petroleum hydrocarbon concentration of the drilling mud. Section 4 reports arithmetic and logarithmic sampling of the petroleum hydrocarbon concentrations and logarithmic sampling of the petroleum hydrocarbon concentrations of the petroleum hydrocarbons.

Although processing methods are the most common hydrocarbon analysis in drilling muds, the hydrocarbon fingerprint concentration methods are not usually effective for petroleum hydrocarbons present in drilling mud and petroleum hydrocarbons in the drilling mud.

(6.2) Revised Protocol for Disposal of Hydrocarbon-Impacted Drilling Wastes

The occurrence of a hydrocarbon fingerprint for concentrations of BTEX and 24 polycyclic hydrocarbon components within the drilling mud is the recommended method to calculate aerosol data from which are used for assessing and limiting recording the values in table 6.1 for the applicable land use and soil type. Arithmetic sampling of the petroleum hydrocarbon concentrations of the BTEX and 24 hydrocarbon components within the drilling mud is the values as in table 6.1.

The following calculations are to be used to calculate the concentration of hydrocarbons in the liquid petroleum, assuming a mix ratio of 1 part water to 1 parts soil (petroleum hydrocarbon) to the other two values as applicable, and an aggregate of the hydrocarbon concentrations.

$$S_{ac} = \frac{S_{ac} \cdot (1000 \text{ kg/m}^3)}{(1 - 0.001 \text{ kg/m}^3) \cdot (1 - 1000 \text{ kg/m}^3)}$$

where

S_{ac} (mg/kg as C10) = petroleum concentration in soil (water mix, as a dry weight basis)

S_{ac} (mg/kg as C10) = petroleum concentration in the water as a dry weight basis

0.001 kg/m^3 = moisture content (saturated)

1000 kg/m^3 = the dry bulk density of the petroleum hydrocarbon (water saturated) (bulk specific gravity)

Appendix 4 Metals

A4.1 Introduction

Changes or updates to soil quality or remediation guidelines require that the methods of applying wastes to land be re-evaluated to ensure that the resulting soil/waste mix does not exceed the updated guideline values. From a metal perspective, the 1996 edition of *Directive 050* was revised to ensure that disposal operations meet the Alberta Environment *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010) and, if applicable, the Alberta Environment *Soil Remediation Guidelines for Barite* (2009) (refer to section 3.4 for guidance on using the barite guidelines). Metal endpoints for soils receiving drilling wastes have been established based on these documents and are set out in table 3.4.

A4.2 Rationale for Including/Excluding Metals

A number of drilling fluid additives/mud products are used to ensure that the fluid properties are compatible with the geological conditions encountered during drilling. These fluid additives/mud products may contain metals and, depending on the quantities used, may be the source of metal issues. Historic data on metal concentrations in drilling waste collected as part of the 1994 Drilling Waste Review Project concluded that metal analysis of drilling waste was only required when fluid additives/mud products containing significant metal concentrations were added to the drilling mud system.

Metal sources of concern include the following:

- zinc carbonate ($ZnCO_3$), which is commonly used to remove hydrogen sulphide if it is encountered during drilling. In some cases, $ZnCO_3$ is contaminated with cadmium. If the drilling waste needs to be analyzed for $ZnCO_3$, cadmium should also be measured.
- barite ($BaSO_4$), which is used to increase fluid density, and
- chrome lignosulphonates, which were commonly used as thinners at one time, but have been largely phased out.

Drilling wastes must continue to be analyzed for metals when the cumulative concentration of metals in the fluid additives/mud products added to the drilling mud system exceeds the values for any of the metals in table 3.4. The entire mud list must be reviewed and all of the additives/products containing the metals listed in table 3.4 must be considered when determining the need to analyze the drilling waste. Metal data for additives/products must be gathered from material safety data sheets or other product specification information obtained from the additive/product manufacturer. If there is not sufficient information to determine the metal concentration in all the additives/products used in the drilling mud system, the drilling waste must be analyzed for metals.

Licensees can also obtain metal information for a drilling mud system by developing and analyzing a "generic mud system" as described in section 4.4. The results of the metal analysis of the drilling waste must be used to calculate appropriate soil/waste mix or spread ratios to ensure that the soil endpoints set out in table 3.4 are not exceeded.

The following can be used to calculate the concentration of a metal after mixing the drilling waste with the receiving soil, assuming a m_r = ratio of 1 part waste to 3 parts soil (substitute appropriate numbers for other mix ratios as applicable):

$$P_m = \frac{(P_w \times DBD) + [P_s \times 3 \times 1540\ (kg/m^3)]}{[3 \times 1540\ (kg/m^3)] + DBD\ (kg/m^3)}$$

where

P_m = parameter concentration in soil/waste mix on a dry weight basis (mg/kg or %)

P_w = parameter concentration in the waste on a dry weight basis (mg/kg or %)

DBD (kg/m^3) = the dry bulk density of the solids, or total waste calculated from specific gravity

P_s = parameter concentration in the soil on a dry weight basis (mg/kg or %)

1540 (kg/m^3) = receiving soil density (subsoil)

The metal concentrations set out in table 3.5a, which trigger the requirement to post-disposal sample the soil/waste mix, are in mg/kg wet weight and are correlated to the specific gravity (SG) of the drilling waste. The concentrations were calculated using Alberta-specific background soil metal concentrations from Alberta Environment and Parks, Alberta Tier 1 de-minimus soil guideline values (2016) for metals, and a soil-to-waste mix ratio of 3 to 1.

The boron concentrations set out in table 3.5b, which also trigger the requirement to post-disposal sample the soil/waste mix, are in mg/L of waste filtrate or saturated paste extract and are correlated to the specific gravity of the drilling waste. The following formulas were used to calculate the concentrations based on Alberta-specific background soil boron concentrations from Alberta Environment and Parks, Alberta Tier 1 de-minimus soil guidelines (2016), a soil-to-waste mix ratio of 3 to 1, a saturation of 50 per cent in both the soil and soil/waste mix, and a saturation of 120 per cent for waste saturated pastes.

$$Cf\,(mg/L) = \frac{\left\{Tier\,1 \times \frac{SPm}{100} \times [(3 \times 1.54) + (2.65 \times \frac{SGf - 1}{1.65})]\right\} - (Cssp \times \frac{SPs}{100} \times 1.54 \times 3)}{\frac{2.65 - SGf}{1.65}}$$

$$Csp\,(mg/L) = \frac{\left\{Tier\,1 \times \frac{SPm}{100} \times [(3 \times 1.54) + (2.65 \times \frac{SG - 1}{1.65})]\right\} - (Cssp \times \frac{SPs}{100} \times 1.54 \times 3)}{\frac{SPw}{100} \times 2.65 \times \frac{(SG - 1)}{1.65}}$$

where

Cf = boron concentration in waste filtrate (mg/L)

Tier 1 = Alberta Tier 1 de-minimus boron concentration (3.3 mg/L)

SPm = saturation % in soil/waste mix (50%)

Cssp = boron concentration in the soil saturated paste extract (Alberta-specific background soil concentration of 0.1 mg/L)

SGf = specific gravity of oversaturated waste (Mg/m^3)

Csp = boron concentration in saturated paste extract (mg/L)

SG = wet density of the undersaturated waste (Mg/m^3)

SPs = saturation % in background soil (50%)

SPw = saturation % in waste saturated paste (120%)

Appendix 5 Toxicity Testing

A5.1 Introduction

A number of drilling fluid additives/mud products are used to ensure that the fluid properties are compatible with the geological conditions encountered during drilling. Some of these fluid additives/mud products may have toxicity concerns. Toxicity testing of drilling wastes can be used to determine whether components that might be harmful to vegetation, micro-organisms, aquatic species, wildlife, or humans and are not detected in routine chemical analysis are present. Toxicity testing can also be useful in predicting the influence of environmental factors on ecotoxic responses and the short- and long-term impacts of drilling wastes.

Toxicity tests that are suited to the testing of drilling waste material must be responsive to components that are organic, metallic, organometallic, or gaseous and should not be highly dependent on major nutrient or ion concentrations.

Toxicity tests are conducted on drilling waste to

- determine the presence or absence of toxicity,
- ascertain the nature, extent, and probable cause of toxicity,
- assist in developing and evaluating waste treatment options, and
- assist in making waste disposal decisions.

An evaluation of potential toxicity is required for the fluids, solids, or total waste components of all drilling wastes. Examining the mud products used and the operations at the well site can provide guidance as to whether toxicity testing is required. When toxic effects are identified, the source of the effects must be identified and properly managed as part of the overall disposal plan.

The 1996 edition of *Directive 050* identified the Microtox® toxicity test, which uses a luminescent bacterium as the test organism, as the established standard for evaluating the toxicity of drilling fluid additives/mud products and the potential toxicity of drilling wastes. This microbial test is used as a cost-effective alternative to the rainbow trout acute lethality test. The 2012 edition of *Directive 050* retained the luminescent bacterial toxicity test but also introduced the concept of using terrestrial toxicity testing as an alternative in situations where the luminescent bacteria toxicity test is not suitable for the product/drilling waste being tested (e.g., because of physical interference or atypical dose response).

The following sections are focused on water-based drilling fluids; other mud systems require specific management and disposal plans. The mechanism that will be used to evaluate the toxicity of the system must be addressed in the management plan.

A5.2 Luminescent Bacteria Toxicity Test and Pass Threshold

The 1996 edition of *Directive 050* also described the Microtox methodology, including the standard assay procedure (SAP; testing an osmotically adjusted sample at the highest concentration of 45 per cent) and the increased sensitivity assay procedure (ISA; testing an osmotically adjusted sample at the highest concentration of 81.8 per cent). The directive set a pass threshold of 75 per cent for an EC50(15) (i.e., the aqueous concentration of the drilling waste or drilling fluid additive/mud product that halves the initial light output of the luminescent bacteria after 15 minutes must be 75 per cent or greater).

This edition of *Directive 050* retains the luminescent bacteria toxicity test as a standard, and it retains a pass threshold of 75 per cent for an EC50(15), but it does not include the Microtox methodology or procedures. See the references below for the methodology and procedures for toxicity testing using luminescent bacteria.

Aqueous phase samples

MicrotoxOmni Software, v. 1.18 ©2003 Strategic Diagnostics Inc. (for additional information, call 800-544-8881 or visit www.sdix.com).

American Public Health Association, American Water Works Association, and Water Environment Federation. Method 8050: Bacterial Bioluminescence. *Standard Methods for the Examination of Water and Wastewater*, 21st edition.

Western Canada Microtox Users Committee. *Standard Procedures for Microtox Analysis*. 1994. Report AECV94-G1, available from www.wcmuc.com.

Environment Canada. *Biological Test Method: Toxicity Test Using Luminescent Bacteria*. Report EPS 1/RM/24, 1992.

The Open Environmental Pollution & Toxicology Journal, 2010, Volume 2: 1–7. *Turbidity and Color Correction in the Microtox™ Bioassay*. John Ashworth, Erik Nijenhuis, Bozena Glowacka, Lang Tran, and Lisa Schenk-Watt.

Solid phase samples

Environment Canada. *Biological Test Method: Reference Method for Determining the Toxicity of Sediment Using Luminescent Bacteria in Solid-Phase Test*. Report EPS 1/RM/42, 2002.

A5.2.1 Luminescent Bacteria Toxicity Test Limitations, Interferences, and Sample Handling

Under advisement from the Western Canada Microtox Users Committee, sample preparation techniques specific to the luminescent bacteria test method for the assessment of drilling waste toxicity have been retained in this edition of *Directive 050* and are set out below. However, licensees are reminded of this directive's section 5, which requires that methods used to assess drilling waste be recognized and published, preferably methods for which SCC or CALA accreditation had been obtained or is expected.

A5.2.2 Luminescent Bacteria Toxicity Test: Limitations and Interferences

Colour (especially red and brown), turbidity, suspended solids, and floating or emulsified substances interfere with this test by absorbing or reflecting light and thereby affecting or causing nonspecific reductions in light output. The absorbance (colour) correction procedure should be used to correct for these interferences. The procedure provides a means for mathematically adjusting the light emission readings to account for light lost due to adsorption, and allows the testing of coloured or slightly turbid test samples. Highly turbid or emulsified samples should be clarified as much as possible by centrifuging and decanting prior to testing.

A high salt concentration in test samples (i.e., in excess of 30 g/L NaCl) may produce hyperosmotic effects upon addition of NaCl as required in the toxicity test. No osmotic adjustment should be made if the salt concentration in the sample is between 30 to 50 g/L NaCl equivalent.

Presence of volatiles may affect the test results or reproducibility. However, unless aeration or excessive mixing is performed on the samples, volatile components should not be excessively lost.

Test-sample pH may inhibit light output and affect test results. Ideally, the test-sample pH should not be adjusted because the test relevance and sample integrity may become questionable. Altering the test-sample pH will usually change the solubility of both organic and inorganic constituents. Modifying the pH can also cause chemical reactions that will change the sample matrix and integrity and greatly alter the exhibited toxicity of the sample. The pH should be adjusted only in samples that have a pH below 6.0 or above 8.8 to minimize any potential effects due to pH alone.

A5.2.3 Luminescent Bacteria Toxicity Test: Fluids Sample Handling – Clarification

Drilling waste material will be in one of three phases: fluid, sludge, or solid. In practice, samples cannot be neatly categorized as they may range from clear liquids to slightly turbid waste, to highly turbid waste, to thick sludge, to solids.

The toxicity test must be performed on a liquid portion of the samples as received. In order to match on-site disposal as far as possible, toxicity testing in the lab should be done with the

minimum of sample preparation. Turbidity/colour-correction procedures must accurately correct for any effects on apparent sample toxicity caused by colour and/or sample turbidity (measured in nephelometric turbidity units, NTU).

A5.2.4 Luminescent Bacteria Toxicity Test: Solids Sample Handling – Aqueous Extraction Procedure

The testing of solids samples, such as thick sludges, solids, and drill cuttings, will require the preparation of an aqueous extract prior to toxicity testing as follows:

1) Perform a 1:1 extraction as follows:

   a) to 25 g of the solids sample as received, add 25 mL of demineralized water in a clean glass container, and

   b) close the container with a Teflon-lined cap or parafilm.

2) Place the container on a wrist-action shaker at the maximum mixing are for one hour. If a wrist-action shaker is unavailable, a suitable mechanical shaker may be used, providing there is complete mixing between the solid and fluid phases. Ensure that the maximum surface contact is obtained. Record the type of shaker used (this is not required to be reported but is used for interpreting and comparing results).

3) Transfer the aqueous extract solution to a glass centrifuge tube using a glass pipette. If glass centrifuge tubes are unavailable, nontoxic plastic tubes may be used. Record the type of centrifuge tube used (this is not required to be reported but is used for interpreting and comparing results).

4) Clarify the extract by centrifuging at 16 000 × g for 10 minutes in a refrigerated centrifuge at approximately 10 to 15°C, if possible. If refrigerated centrifuge at this g-force is unavailable, cool the sample to 10°C prior to centrifugation at the maximum attainable g-force for your centrifuge. Record the speed, g-force, and temperature used for centrifugation. If the aqueous phase does not appear clear after centrifugation, re-centrifuge in a clean centrifuge tube. (The sample should be clarified so that colour correction has little or no effect.)

5) Immediately transfer the aqueous supernatant to a clean glass container. Close the container with a Teflon-lined cap.

AS 2.5 Luminescent Bacteria Toxicity Test: Drilling Waste Charcoal Treatment Procedure

Drilling wastes that demonstrate a toxic response to luminescent bacteria should have a sample of it retested after being treated with charcoal to identify whether hydrocarbons are contributing to the observed toxicity or whether further characterization is required to determine the source of toxicity (refer to section 4.3, requirements 5 through 9). Understanding the source of toxicity can provide insight into potential field treatment methods that could be used to reduce the toxicity of the drilling waste.

Charcoal treatment will help determine whether the toxic components will adsorb in similar environmental conditions following disposal. (This treatment has historically been used to successfully remove hydrocarbon contamination from a sample, but it should not be considered solely indicative of hydrocarbon contamination.)

In order to achieve comparable results for charcoal treatment of drilling wastes, it is imperative that lab analysis adhere to the following procedures. Any deviation from these procedures would result in invalid results.

Preparation of Charcoal

1) Use a good-quality, granular-activated charcoal, such as bone- or hardwood-derived charcoal suitable for use in fish aquariums, 10 to 20 mesh size. The use of Norchar or other powder forms of charcoal is not acceptable.
2) Prewash the charcoal by placing about 2 kg in a plastic colander or fine nylon mesh sieve and rinsing for several minutes with hot tap water followed by high-purity demineralized water. Ensure that all charcoal fines are removed during this step. Repeat rinsing step, if necessary.
3) Dry the washed charcoal at 105°C in a clean, organic-vapour-free drying oven for 16 hours.
4) Cool to room temperature and store in a clean, tightly closed glass container.

Charcoal Treatment Procedure

1) Transfer 5 mL of a clarified, pH-adjusted sample into a clean 10 mL glass test tube fitted with a polyethylene cap.
2) Add 0.60 g of prepared activated charcoal.
3) Shake tube gently for about 10 seconds every 2 minutes for a total of 10 minutes.
4) Allow the charcoal to settle for 30 minutes. Do not allow the settling time to extend past 30 minutes. Shake the tube gently.
5) Perform the toxicity test on the sample, following the SAP or ISA procedure.

Quality Control for Charcoal Treatment Procedure

1) Test the pre-settled activated charcoal for the presence of toxicants on a regular basis by substituting high-purity, toxicant-free demineralized water for the test sample and following the charcoal treatment procedure described above.

2) Perform the toxicity test on the charcoal-treated demineralized water and the untreated demineralized water (as an analytical blank).

3) Follow this quality control procedure whenever charcoal treatment is used.

A8.3 Alternative Toxicity Testing

The luminescent bacteria toxicity test may not be suitable for testing all drilling mud products and drilling wastes. Certain categories of products, such as starches or those that are insoluble, could give false dose responses with the luminescent bacteria and do not allow an accurate endpoint for the products to be established. Terrestrial toxicity testing is an additional step in the toxicity assessment process and can be used to

- provide soil toxicological data on the effect of a known concentration of a mud product/additive on plants and invertebrate species native to Alberta,
- establish a threshold toxicity level for mud products/additives, the proponent must provide information to support the claim that luminescent bacteria toxicity testing is not suitable for the mud product/additive, or
- assess the potential to land-apply drilling wastes.

The strength of terrestrial toxicity tests is that organisms from different terrestrial trophic levels are used to assess toxicity and the appropriateness of land application of drilling wastes. The specific procedures for terrestrial toxicity testing of fluid additives/mud products or drilling wastes are outlined in the following Environment Canada soil toxicity test methods, which must be used to develop a plan for approval of land application of the drilling wastes:

- *Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil* (Report EPS 1/RM/45, 2005),
- *Test for Measuring Survival and Reproduction Effects in Springtails Exposed to Contaminants in Soil* (Report EPS 1/RM/47, 2007), and
- *Tests for Toxicity of Soil Contaminants to Earthworms* (*Eisenia Andrei*, *Eisenia fetida* or *Lumbricus terrestris*) (Report EPS 1/RM/43, 2004).

The plan should include the development of a suitable matrix that reflects conditions at the field. The matrix, therefore, should be a blend of 1 part product, mud system, or drilling waste to 1 parts soil. Incorporation of waste into artificial or site-referenced soil is allowed. However, use of artificial soil following the recipe outlined in the Environment Canada methods will reduce variability in sample handling, allow standardized base soil to be used between labs, and allow any effects observed to be discerned from the product or waste being tested rather than from natural impairment that might be imparted from the site soil.

The Environment Canada soil toxicity test methods use inhibition concentration causing 50 per cent effect on exposed test organisms (IC 50) as a principal endpoint. IC 50 is used when quantitative (or continuous) data are being analyzed (i.e., growth or reproduction), whereas LC 50, the concentration of material in water, soil, or sediment that is estimated to be lethal to 50 per cent of the test organisms, and EC 50 are statistical endpoints for tests using a quantal (or count) type approach (i.e., survival, avoidance behaviour). Further explanation on this matter, as well as on statistical methods of analyzing toxicity test data, can be found in the Environment Canada *Guidance Document on Application and Interpretation of Single-species Tests in Environmental Toxicology* (Reggett EPS 1/RM/34, 1999) and *Guidance Document on Statistical Methods for Environmental Toxicity Tests* (Reggett EPS 1/RM/46, 2005).

Other references related to soil and toxicity assessment include the following:

- *Alberta Tier 1 Guidelines for Soil and Groundwater Remediation*. 2010. Alberta Environment and Sustainable Resource Development.
- *Alberta Tier 2 Guidelines for Soil and Groundwater Remediation*. 2009b. Alberta Environment.
- *A Protocol for the Derivation of Human Health and Ecological Soil Quality Guidelines*. 2006. Canadian Council of Ministers of the Environment. PN 1332.
- *Canada-Wide Standards for Petroleum Hydrocarbons (PHC's) in Soil*. 2001. CCME. Draft, and
- *Tier 2 Ecocontact Guideline Derivation Protocol*. 2007. Alberta Environment. Draft.

The onus is on licensees to obtain toxicity testing information for fluid additives/mud products used in the drilling mud formulation. In situations where luminescent bacteria toxicity information is not available, the licensee must develop a toxicity testing program and gather the data to develop toxicity threshold levels that would be equivalent to those developed using the luminescent bacteria testing method. This program must be provided to the AER for review and approval before implementing it.

In situations where the reason why the drilling waste failed the luminescent bacteria bioassay cannot be determined and the licensee wishes to land apply the drilling waste, the onus is on the

[illegible] to develop a corrosion testing program and gather the data to support that the disposal of the drilling waste is not toxic to the soil environment. Information to support that the soil waste does not exceed the salt, hydrocarbon, and trace element [illegible] set out in section 11 of the directive must be collected before proceeding to the development of a corrosion testing program. This program must be specified in the AER for review and approval before it is implemented.

Appendix B — Drilling Waste Sample Handling, Analytical Methods, and Interpretation

B1.1 Data Quality

Drill cuttings are rock fragments broken by the drilling process and carried to the surface by drilling fluid. They are the most direct physical record of the formations penetrated by the well. Because they are small, irregular, and mixed with drilling fluid, cuttings require careful handling and preparation before any meaningful analysis can be performed.

B1.2 Sample Handling and Preparation

Drilling fluids can be water-based, oil-based or synthetic-based. Water-based muds are the most environmentally acceptable and are used wherever technically feasible. Oil-based and synthetic-based muds are used for challenging formations but require more careful handling and disposal.

Sample handling and preparation differ depending on whether the drilling fluid is water-based or oil-based. Drilling fluid type must be known before any sample is collected, because it determines how the sample is washed, stored, and prepared for analysis.

The primary goal is to remove drilling fluid from the cuttings while preserving the rock material for analysis. Water-based mud samples are washed with water, while oil-based mud samples require solvent cleaning. Failure to properly remove drilling fluid can contaminate the sample and affect the results.

The following procedures are commonly used for sample preparation. The choice of procedure depends on the type of drilling fluid used.

Water-based mud: Water-based mud samples are washed with water to remove the drilling fluid. The cuttings are then dried and stored in labeled containers. Water-based mud is the most environmentally acceptable drilling fluid and is preferred wherever technically feasible.

Oil-based mud: Oil-based mud samples require solvent cleaning before analysis. The cuttings are washed with a suitable solvent to remove the oil, then dried and stored in labeled containers. Oil-based mud is used for challenging formations but requires careful handling and disposal.

Synthetic-based mud: Synthetic-based mud samples are handled in the same way as oil-based mud samples. The cuttings are washed with a suitable solvent, dried, and stored in labeled containers. Synthetic-based mud is used for challenging formations but requires careful handling and disposal.

$$\text{DMD (kg/m}^3\text{)} = \frac{[\text{Measured mud density (kg/m}^3\text{)} - 1000\ \text{(kg/m}^3\text{)}] \times 2.65\ \text{(g/mL)}}{2.65\ \text{(g/mL)} - 1\ \text{(g/mL)}}$$

where

DMD = dry weight of solids in a given volume of wet waste

Measured mud density (kg/m^3) = SG × 1000

2.65 (g/mL) = particle density of solids

Density of water = 1000 kg/m^3 = 1 g/mL

To convert a parameter from mg/L of filtrate from the as-received (oversaturated) sample to mg/kg of dried waste solids:

$$P_s\ \text{(mg/kg)} = P_{filtrate}\ \text{(mg/L)} \times \left[\frac{(2650 - \text{DMD})}{(2.65 \times \text{DMD})}\right]$$

where

P_s (mg/kg) = the concentration of the parameter in the dried waste solids

$P_{filtrate}$ (mg/L) = the concentration of the parameter in the as-received filtrate

DMD (kg/m^3) = the dry bulk density (from above calculations)

2.65 (g/mL) = particle density of solids

2650 = 2.65 × 1000

To determine the volume fraction of water in as-received (oversaturated) waste materials:

$$\text{Volume fraction of water } (\Phi) = 1 - \left[\frac{\text{Mud density} - 1000}{1650}\right]$$

where

Mud density (kg/m^3) = SG × 1000

b) Undersaturated Drilling Waste Materials Equations

The DRD of an undersaturated sample is estimated using the same equation as for an oversaturated sample; however, the SG is measured as described in subsection A6.2.1.

Analysis of undersaturated solids requires, as a separate, additional step, the preparation of a saturated paste as follows:

1) Add distilled water to bring a subsample to a saturated paste condition, mix and allow to sit for a minimum of four hours so that the salts can equilibrate with the added water.

2) Determine the SG of the saturated paste using the API mud balance.

3) Filter the saturated paste and analyze the extract for major ions and nitrogen, if required.

To determine the volume fraction of water in a saturated paste made from an undersaturated waste material:

$$\text{Volume fraction water } (\Phi_w) = \frac{(2.65 - SG)}{1.65}$$

where

SG = specific gravity of the saturated paste is measured using the API mud balance

2.65 (g/mL) = particle density of solids

To convert a parameter from mg/L of filtrate from a saturated paste extract to mg/kg of dried waste solids:

$$P_s \text{ (mg/kg)} = P_{filtrate} \text{ (mg/L)} \times \left[\frac{\Phi_w}{2.65 \times (1 - \Phi_w)}\right]$$

where

P_s (mg/kg) = the concentration of the parameter in the dried solids

$P_{filtrate}$ (mg/L) = the concentration of the parameter in the saturated paste filtrate

Φ_w = the volume fraction of water

2.65 (g/mL) = particle density of solids

c) Equations to Predict the Mass of a Parameter in Drilling Wastes

To predict the mass of trace elements in a given volume of either **oversaturated or undersaturated waste material**:

$$\text{Mass (kg)} = \frac{P_w \text{ (mg/kg)} \times \text{DBD (kg/m}^3\text{)} \times \text{Volume (m}^3\text{)}}{10^6 \text{ (mg/kg)}}$$

where

P_w (mg/kg) = the concentration of the parameter in the dried solids

DBD (kg/m^3) = dry bulk density calculated from SG

Volume (m^3) = volume of drilling waste material

To calculate the mass of a parameter in a given volume of a **clear waste liquid**:

$$\text{Mass (kg)} = P_L \text{ (mg/L)} \times \left[\frac{\text{Clear waste liquid volume (m}^3\text{)}}{1000}\right]$$

where

P_L (mg/L) = the concentration of the parameter in the clear waste liquid

A6.3.2 Disposal Limit Equations

The following calculations can be used to predict soil/waste mix ratios, maximum waste application rates, minimum disposal areas, amount of a parameter per hectare of land, and amount of a parameter in the resulting soil/waste mix. For all salinity equations see appendix 2.

a) MBC Equations

To calculate the concentration of any parameter in the soil/waste mixture for a mix ratio of 1 part waste to 3 parts soil (substitute appropriate numbers for other mix ratios as applicable) when, for practical purposes, it can be assumed that the receiving soil contains none of that parameter (e.g., hydrocarbon):

$$P_m = \frac{P_w \times \text{DBD (kg/m}^3\text{)}}{[3 \times 1540 \text{ (kg/m}^3\text{)}] + \text{DBD (kg/m}^3\text{)}}$$

where

P_m (mg/kg or %) = parameter concentration in soil/waste mix on a dry weight basis

P_w (mg/kg or %) = parameter concentration in the waste on a dry weight basis

1540 kg/m^3 = receiving soil density (subsoil)

DBD (kg/m^3) = the dry bulk density of the solids or total waste calculated from SG

To calculate the concentration of a parameter after mixing when the receiving soil already contains a background level of that parameter (i.e., a trace element) for a mix ratio of 1 part waste to 3 parts soil (substitute appropriate numbers for other mix ratios as applicable):

$$P_m = \frac{[P_w \times \text{DBD (kg/m}^3)] + [P_s \times 3 \times 1540 \text{ (kg/m}^3)]}{[3 \times 1540 \text{ (kg/m}^3)] + \text{DBD (kg/m}^3)}$$

where

P_m (mg/kg or %) = parameter concentration in soil/waste mix on a dry weight basis

P_w (mg/kg or %) = parameter concentration in the waste on a dry weight basis

P_s (mg/kg or %) = parameter concentration in the soil on a dry weight basis

1540 kg/m^3 = receiving soil density (subsoil)

DBD (kg/m^3) = the dry bulk density of the solids or total waste calculated from SG

b) Equations for Landspreading, Landspraying, Disposal onto Forested Public Lands, Landspray While Drilling, and Land Treatment

To calculate the maximum application rate that will not exceed the kg/ha loading limit for a given parameter (e.g., sodium):

$$\text{Maximum application rate (m}^3\text{/ha)} = P_{max} \text{ (kg/ha)} \times \left[\frac{10^6 \text{ (mg/kg)}}{P_w \text{ (mg/kg)} \times \text{DBD (kg/m}^3\text{)}} \right]$$

where

P_{max} (kg/ha) = the maximum amount of a parameter (limit) allowed on 1 ha

P_w (mg/kg) = the concentration of a parameter in the dry solids (calculated from filtrate results)

DBD (kg/m^3) = the dry bulk density of the solids or total waste calculated from SG

To calculate maximum application thickness (cannot exceed one-third of the incorporated depth or 10 cm, whichever is less).

$$\text{Maximum application thickness (cm)} = \frac{\text{Maximum application rate } (m^3/ha)}{100}$$

To calculate the minimum area required for disposal so that the limit for a given parameter (e.g., sodium) is not exceeded, substitute (a) the maximum calculated application rate, (b) 1000 m^3/ha, or (c) incorporated depth (cm)/3 × 100, whichever is less, into the equation below. Licensees are encouraged to use more than the minimum area, if available.

$$\text{Minimum disposal area (ha)} = \frac{\text{Volume of undersaturated solids } (m^3)}{\text{(a) or (b) or (c)}}$$

Where applicable, a simple approach to determine minimum disposal area is to divide the waste volume by the maximum application rate equation.

To calculate the amount of any parameter added to the receiving soil:

$$\text{Amount (kg/ha)} = \frac{P_w \text{ (mg/kg)} \times \text{DBD } (kg/m^3) \times \text{Maximum application rate } (m^3/ha)}{10^6 \text{ (mg/kg)}}$$

where

P_w (mg/kg) = the concentration of a parameter in the dry solids (calculated from filtrate concentrations)

DBD (kg/m^3) = dry bulk density calculated from SG

Maximum application rate (m^3/ha) = value calculated from the above equation

To calculate the amount per hectare of any parameter added to the receiving soil:

$$\text{Amount (kg/ha)} = \frac{\text{Mass of the parameter (kg)}}{\text{Planned disposal area (ha)}}$$

c) Equation Specific for Landspraying and Landspray While Drilling

To calculate the maximum application rate that will not exceed 6 t/ha loading limit for landspraying and landspray-while-drilling disposal methods:

$$\text{Maximum application rate } (m^3/ha) = \frac{6\ (t/ha) \times 1000\ (kg/t)}{DBD\ (kg/m^3)}$$

where

DBD (kg/m^3) = dry bulk density calculated from SG of the oversaturated solids or total waste

d) Pump-off Equations

To calculate the maximum application rate of clear drilling waste liquid that will not exceed the rate limitation for a dissolved parameter:

$$\text{Maximum application rate } (m^3/ha) = \frac{P_{max}\ (kg/ha) \times 10^{-3}\ (m^3/L) \times 10^{6}\ (mg/kg)}{P_L\ (mg/L)}$$

where

P_{max} (kg/ha) = the maximum application rate allowed on 1 ha of land

P_L (mg/L) = the concentration of the parameter in the clear waste liquid

If the calculated rate is greater than 1000 m^3/ha, apply the clear waste liquid at a maximum rate of 1000 m^3/ha. This is equivalent to a 10 cm layer of application.

To calculate the minimum area required for disposal of clear waste liquid without exceeding the parameter limit, substitute (a) the maximum application rate or (b) 1000 m^3/ha, whichever is less, into the equation below. Licensees are encouraged to use more than the minimum disposal area, if it is available.

$$\text{Minimum disposal area (ha)} = \frac{\text{Volume of clear waste liquids } (m^3)}{\text{(a) or (b)}}$$

Where applicable, a simple approach to determine minimum disposal area is to divide the waste volume by the maximum application rate equation.

To calculate the amount per hectare of any dissolved parameter added to the receiving site:

$$\text{Amount (kg/ha)} = P_L \text{ (mg/L)} \times \left[\frac{\text{Application rate } (m^3/ha)}{1000} \right]$$

where

P_L (mg/L) = the concentration of the parameter in the clear waste liquid

Appendix 7 Definitions of Terms as Used in *Directive 050*

Advanced gel chemical	Water-based drilling mud system in which a significant primary component such as salt or polymer has been added to aid in the drilling. Examples include potassium silicate, potassium sulphate, potassium nitrate, and amines.
Alternative storage system	Above-ground tanks or other storage vessels, sumps lined with a synthetic liner, or other storage system approved by the AER used to store drilling wastes.
Approved waste management facility	A facility that is approved under the *Oil and Gas Conservation Act* and the rules under that act or that is approved under the *Environmental Protection and Enhancement Act* and the regulations under that act to process, treat, dispose of, store, or recycle wastes.
Atterberg limits	A basic measure of the nature of a fine-grained soil. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic, and liquid. In each state, the consistency and behaviour of a soil is different and thus so are its engineering properties. The Atterberg limits can be used to distinguish between silt and clay, and it can distinguish between different types of silts and clays.
Bentonite	A type of clay, the main constituent used in freshwater gel drilling mud systems.
Berm	A raised earthen barrier constructed of clayey soils used for containment.
Bioassay	The assessment of a potential biological impact of a substance by quantifying its effect on a representative test organism employing a standardized protocol.
BTEX	Collective abbreviation for the light-end volatile hydrocarbons benzene (B), toluene (T), ethylbenzene (E), and xylenes (X).
Biodegradation	The breakdown of organic contaminants by microbial organisms into smaller compounds. The microbial organisms transform the contaminants through metabolic or enzymatic processes. Biodegradation processes vary, but frequently the final product of the degradation is carbon dioxide or methane.
Bulk density (soil)	The mass of dry soil per unit volume (kg/m^3). The bulk volume is determined before the soil is dried to constant weight at 105°C.

Bulking agent	Material added to increase the surface area of waste. Examples include woodchips, sawdust, and humalite. Note that required characterization, tests, and analyses must be conducted on the drilling waste prior to the addition of bulking agents.
Calculated mix ratio	Soil-to-waste mix ration determined through the use of calculations listed in appendices 2, 3, 4, and 6.
Cement returns	Excess cement circulated to the surface after downhole cementing.
Clay	A mineral soil consisting of particles less than 0.002 mm in diameter, a soil textural class, or a fine-grained soil that has a high plasticity index relative to the liquid limit.
Clayey soil	Soil that has greater than 50 per cent fines (defined as dry weight percentage passing a no. 200 sieve), greater than 20 per cent clay (i.e., 0.002 mm or smaller as defined by the hydrometer method), a liquid limit equal to or greater than 30 per cent, and a plasticity index equal to or greater than 10 per cent.
Coarse soil	Soils that have a median grain size greater than 75 microns.
Composite sample	A sample consisting of equal parts of a number of subsamples taken from specific locations/areas/depths such that the composite sample is representative of the whole volume or mass of material being sampled.
Contaminated drilling wastes	Drilling wastes containing materials, other than drilling fluid/mud system, cuttings, formation materials, and precipitation that are foreign to the drilling activity. Examples of contaminant materials include drill-stem testing fluids, rig wash fluids, camp wastes, and other oilfield wastes. Contaminated wastes are to be handled following the most restrictive requirements that apply.
Crown disposition	The administrative and operating conditions assigned for use of public lands in the form of a lease, license, permit, or letter of authority, administered by the AER or EP.
Crown disposition holder	A person or party that has been assigned use of public lands (e.g., lease, license, or permit) issued under the provisions of the *Public Lands Act*.
Cultivated land	Agricultural land that has been worked by ploughing and sowing and raising crops.

Cumulative concentration	The calculated value of a substance in a drilling waste once all possible sources have been taken into account.
Dilution	Mixing of a liquid or solid (waste) with another liquid or solid for the primary purpose of reducing the concentration of the original liquid or solid. Dilution of wastes to meet disposal criteria is prohibited.
Disposal area	The area of land upon which drilling waste was applied or into which drilling waste was mixed.
Disposal cubic cemented pebble facility	A drilling waste disposal method that is similar to landspray and landspray while drilling but that allows higher application rates and is limited to some provincial Crown lands for which the AER has issued specific types of dispositions pursuant to the *Public Lands Act*.
Disposal site	The land used for disposal of wastes.
Dissolved hydrocarbons	Hydrocarbons partitioned into the water phase of drilling wastes.
Drilling cuttings	The small pieces of formation rock and subsurface materials that break away because of the action of drill bit teeth as a well or diversion borehole is being drilled.
Drilling fluid	A suspension, usually in water but sometimes in oil (diesel), used to assist drilling, consisting of various substances in a fluid, divided into (commonly) bentonite clays and chemical additives), introduced continuously down the drill pipe under pressure and through openings in the drill bit and transported back up in the annular space between the pipe and the walls of the hole to a surface pit or tank where it is conditioned and reintroduced into the wellbore. It is used to lubricate and cool the bit, carry the cuttings up from the bottom, and prevent blowouts and cave-ins.
Drilling waste	The muds and cuttings generated while drilling a well and by directional drilling for the purpose of pipeline construction.
Drilling waste other liquids	Liquids separating from water-based drilling wastes. The liquids appear somewhat when sampled at the discharge point and qualify for pump-off. The clear liquids may be colourless or may have natural colour or staining.
Drilling waste fluids	The fluid portion of drilling wastes consisting of a mixture of water, drilling muds, fine cuttings, and additives.

Drilling waste solids	The solids portion of drilling wastes consisting of cuttings, drill cuttings, formulated hydrocarbons, weighting materials, and other additives.
Drilling waste / total waste	The entire volume of drilling waste in a pit, sump or storage system consisting of both the liquids and the solids portions.
Dry bulk density	The weight of dry waste per unit volume of in-situ waste (kg/m³).
Earthen-lined storage system	A type of storage system designed to store drilling waste solids that is an earthen structure built on grade and meets design, construction, and operational requirements of this directive.
EC50(24h)	In a bioassay test, the effective concentration of a sample that causes a 50 per cent decrease in light output at 15°C after 24 minutes exposure.
Electrical conductivity	The ability of a solution to carry an electrical current. Refers to the specific electrical conductance of the water, which is a function of the total dissolved solids. High salinity (high EC) affects plant growth and soil quality.
Endpoint	Maximum concentration of a parameter in soil that has most of drilling waste (refer to tables 3.1, 3.2, and 3.3).
Environment	All components of the earth and includes:
	(i) air, land, and water;
	(ii) all layers of the atmosphere;
	(iii) all organic and inorganic matter and living organisms; and
	(iv) all interacting natural systems that include components referred to in subclauses (i) to (iii).
Equivalent land capability	The ability of land to support various land uses, after reasonable and customary activities that a person in the ability that a land prior to an activity being conducted on the land, but the land should land uses will not necessarily be identical.
Expectations	Recommended best practices or guidelines. Enforcement is not assigned to expectations, but they should be given serious consideration.
Fluid mud	Muds that have a resilient yield one Gra (Nat. F) recovery.

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Per cent saturation	The *per cent saturation* or *saturation percentage* (% sat.) of a soil is the moisture content of a saturated paste. The *per cent saturation* value is determined by drying a weighed subsample of the saturated paste of the soil to a constant weight at 105°C. % sat. = 100 × weight loss on drying / oven-dry weight of paste sample
Petroleum hydrocarbon fraction F1	C_6–C_{10} excluding benzene, toluene, ethyl benzene, and xylenes (BTEX), as defined by the Canadian Council of Ministers of the Environment *Canada-Wide Standards for Petroleum Hydrocarbons in Soil* (2008a).
Petroleum hydrocarbon fraction F2	$C_{>10}$–C_{16} as defined by the CCME (2008a).
Petroleum hydrocarbon fraction F3	$C_{>16}$–C_{34} as defined by the CCME (2008a).
Petroleum hydrocarbon fraction F4	$C_{>34}$ as defined by the CCME (2008a).
pH	The degree of acidity or alkalinity of a substance, as measured by the concentration of hydrogen ions. On this scale, pH 1 is a strong acid, pH 14 is a strong alkali, and pH 7 is the point of neutrality.
Plasticity index	A measure of the plasticity of a soil. The PI is the difference between the liquid limit (LL) and the plastic limit (PL): PI = LL – PL
Plastic limit	The water content where soil starts to exhibit plastic behaviour.
Pump-off	A drilling waste disposal method that involves pumping the nontoxic, clear liquid portion of drilling wastes onto the surface of land.
Qualified person	For the purpose of verifying the presence or absence of a water body or characterizing and classifying soils, a qualified person is one who possesses post-secondary education in an applicable discipline or educational equivalencies, has technical knowledge and experience in the specific area, and is acting within his/her area of expertise.

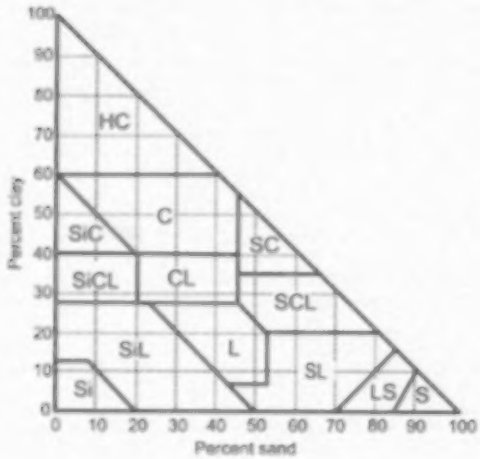
Receiving soil	Soils to which drilling wastes are applied.
Remote site	A well site that receives drilling waste from wells located off the well site for the purpose of storage or biodegradation or a standalone site that is established specifically to receive drilling waste for the purpose of storage or biodegradation and for which the landowner or department/agency managing the land on behalf of the provincial or federal Crown has provided a written agreement (e.g., surface lease, right-of-entry, or disposition under the *Public Lands Act*). When more than one well contributes drilling waste to the remote site, the licensee of all of the wells must be the same.
Requirement	A rule that industry has an obligation to meet and under which the AER may take enforcement in cases of noncompliance.
Rig release	The date on which all drilling operations are complete and the contractor is released from the well site.
Saline soil	A soil with a high content of water-soluble salts and a saturation extract electrical conductivity greater than 4 dS/m. The soil is not sodic.
Saline-sodic soil	A soil with a high content of water-soluble salts and high exchangeable sodium. The soil meets definitions of both saline soil and sodic soil.
Saturated zone	The saturated zone encompasses the below-ground area in which all interconnected openings within the geologic medium are completely filled with water.
Sodic soil	A soil having an exchangeable sodium percentage of 15 or more but is not saline.
Sodium adsorption ratio	A calculated ratio used to represent the relative activity of sodium, calcium, and magnesium with respect to ion exchange reactions in soil. A surrogate for exchangeable sodium percentage.
Soil	The unconsolidated mineral or organic material at the surface of the earth that serves as a medium for plant growth.
Solid	A substance that does not contain free liquids as determined by the US Environmental Protection Agency (EPA) Method 9095 Paint Filter Liquids Test (*Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, EPA Publication SW-846) and is not gaseous at standard conditions.

Sorbent material Material added to facilitate waste handling and to manage any interstitial fluids that could shake out during transportation of the waste. Any required characterization, classification, and analyses for a disposal method must be done on the drilling waste prior to the addition of the sorbent material.

Specific gravity The ratio of the density of a substance to the density of water.

Spud The beginning of drilling operations on a well or borehole.

Soil texture The relative proportions of sand, silt, and clay in a soil as described by the classes of soil texture triangle.



Storage system A type of containment system designed to store materials used, produced, and generated within the upstream petroleum industry and for the purpose of drilling waste, storage systems includes sumps, aboveground tanks and other storage vessels, sumps lined with a synthetic liner, earthen-bermed storage systems, or other storage systems approved by the AER.

Sump A type of storage system designed to store drilling waste that is an earthen excavation and meets the design, construction, and operational requirements of this directive.

Subsoil The layer of soil directly below topsoil that consists of the B and C horizons and extends to bedrock. For salinity management, three depths are recognized: top of the subsoil to a depth of 1 m, subsoil from >1 m to 1.5 m, and subsoil at a depth >1.5 m.

Tank	A device designed to contain materials produced, generated, and used by the upstream petroleum industry that has an internal capacity of more than 1 m^3 and is constructed of impervious materials that provide structural support and may include materials such as plastic, fibreglass-reinforced plastic, or steel but does not include piping. Refer to *Directive 055* for further requirements.
Topsoil	The uppermost layer(s) of soil that consist of L, F, H, O, and/or A horizons or depth of tillage, whichever is greatest.
Total dissolved solids	The concentration of inorganic or mineral constituents dissolved in water, expressed in mg/L. It may be calculated from electrical conductivity.
Total waste sample	A waste sample from the entire depth of the drilling waste sump or storage system. The fluid and solid phases are collected at the same time using a column sampling tube. The required sample is a composite of subsamples from several locations in the sump or storage system.
Undersaturated drilling waste sample	A drilling waste sample in which the pores of the solids are not full of liquids.
Visible hydrocarbons	The observance of a rainbow sheen on drilling waste (fluid portion, clear liquid portion, or total waste), or a total petroleum content (sum of the concentrations of BTEX and F1 through F4 components) within a drilling waste (fluid portion, clear liquid portion, or total waste) that exceeds 100 mg/L.
Water-based drilling muds	A drilling fluid/mud system in which the external phase is water.

Water body

Natural or man-made; contains or conveys water continuously, intermittently, or seasonally.

A natural water body is any location where water flows or is present, whether the flow or presence of the water is continuous, seasonal, intermittent, or occurs only during a flood. This includes, but is not limited to, the bed and shore of a river, stream, lake, creek, lagoon, swamp, marsh, slough, muskeg, or other natural drainage, such as ephemeral draws, wetlands, riparian areas, floodplains, fens, bogs, coulees, and rills.

Examples of a man-made water body include a canal, drainage ditch, reservoir, dugout, or other man-made surface feature.

Waste set

A volume of drilling waste generated from one or more one wells, provided that the generating wells are part of one licensee's drilling program.

Appendix 8 Abbreviations

AER	Alberta Energy Regulator
API	American Petroleum Institute
$BaSO_4$	barite
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAEAL	Canadian Association for Environmental Analytical Laboratories
CALA	Canadian Association for Laboratory Accreditation
CCME	Canadian Council of Ministers of the Environment
Cl	chlorine
cm	centimetre
DBD	dry bulk density
DDS	Digital Data Submission
DFPL	disposal onto forested public lands
DST	drillstem testing
DOW	dangerous oilfield waste
dS/m	decisiemen per metre
EC	electrical conductivity
EP	Alberta Environment and Parks
EPA	Environmental Protection Agency
EPEA	Environmental Protection and Enhancement Act
FIS	field surveillance inspection system
g	gram
ha	hectare
ID	interim directive
IL	informational letter
ILAC	International Laboratory Accreditation Cooperation
ISA	increased sensitivity assay procedure
kg	kilogram
L	litre

LCM	loss circulation materials
LL	liquid limit
LOC	licence of occupation
LWD	landspray while drilling
m^2	square metre
m^3	cubic metre
MBC	mix-bury-cover
Mg	magnesium
MGD	minimum-ground-disturbance
mL	millilitre
mm	millimetre
MSDS	material data safety sheets
MSL	mineral surface lease
N	nitrogen
Na	sodium
NaCl	sodium chloride
NTU	nephelometric turbidity unit
PI	plasticity index
PLA	pipeline agreement
QA/QC	quality assurance / quality control
SAP	standard assay procedure
SG	specific gravity
SAR	sodium adsorption ratio
SCC	Standard Council of Canada
t	tonnes
UWI	unique well identifier
$ZnCO_3$	zinc carbonate

Appendix 9 References

General AER Documents

Directive 051: Injection and Disposal Wells – Well Classifications, Logging, and Testing Requirements

Directive 055: Storage Requirements for the Upstream Petroleum Industry

Directive 056: Energy Development Applications and Schedules

Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry

Informational Letter 98-2: Suspension, Abandonment, Decommissioning, and Surface Land Reclamation of Upstream Oil and Gas Facilities

Interim Directive (ID) 99-4: Disposition of Oilfield Waste into Landfills

ID 2000-3: Waste Harmonization

ID 2000-4: An Update to the Requirements for the Appropriate Management of Oilfield Wastes

Oil and Gas Conservation Act

Oil and Gas Conservation Rules

EP Documents

Administrative Guide for Approvals to Protect Surface Water Bodies Under the Water Act. 2001.

Alberta Environment's Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods. 2003.

Alberta Environment Laboratory Data Quality Assurance Policy Procedures. 2004.

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Assessing Drilling Waste Disposal Areas: Compliance Options for Reclamation Certification. 2012.

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Conservation and Reclamation Regulation

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Policy for Management of Risks at Contaminated Sites in Alberta. 2000.

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Soil Monitoring Directive. 2009.

Soil Remediation Guidelines for Boron: Environmental Health and Human Health. 2009.

Surface Water Quality Guidelines for Use in Alberta. 1999.

Waste Control Regulation

Water Act

Toxicity Testing—Luminescent Bacteria

Aqueous Phase Samples

MicrotoxOmni Software, v. 1.18. ©2003 Strategic Diagnostics Inc. (for additional information call 800 544-8881 or visit www.sdix.com).

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Solid Phase Samples

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Environment Canada. *Test for Measuring Survival and Reproduction Effects in Springtails Exposed to Contaminants in Soil*. Report EPS 1/RM/47. 2007.

Environment Canada. *Tests for Toxicity of Soil Contaminants to Earthworms (Eisenia andrei, Eisenia fetida or Lumbricus terrestris)*. Report EPS 1/RM/41. 2004.

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